Farmers' Management Strategies and the Conservation of Farmland Passerines

Thesis

Link(s) to article on publisher's website:
http://dx.doi.org/doi:10.21954/ou.ro.0000fd39

UNRESTRICTED

Farmers' Management Strategies and the Conservation of Farmland Passerines

Christopher Stoate BA (Hons)

Submitted for PhD

Faculty of Technology

The Open University

2002

DATE OF SUBMISSION: 28 AUGUST 2001

DATE OF AWARD: 7 JANUARY 2002

SUMMARY

Farmers' Management Strategies and the Conservation of Farmland Passerines

Christopher Stoate

- Over the last quarter of the 20th century, population size and range of farmland bird species has declined more than those associated with other habitats. There has been a simplification of the farmland landscape in Britian, and in African areas used by migratory birds in winter. In Britain, game shooting has influenced farm management.
- Changes in bird numbers and nesting success were monitored in relation to game management in Leicestershire. Bird abundance increased during the period of game management. Nationally declining species showed the greatest increases in abundance.
- Hedge height had a negative influence on whitethroat abundance, while herbaceous vegetation had a positive influence on whitethroats and yellowhammers. Survival of yellowhammer nests in herbaceous vegetation was higher than that in hedges. Herbaceous vegetation also has benefits for crop management.
- Farmers' management of field boundary vegetation was studied in Wiltshire. Only farmers with game and conservation interests claimed to adopt field boundary

management that would benefit whitethroats, but across all farms, actual habitat management was generally not suited to whitethroats.

- In Senegambia, the management of shrubby vegetation by farmers, and their motivation for that management, were explored using participatory techniques. Whitethroats were associated with shrub species supporting invertebrates. Farmers reported declines in shrubs, soil fertility and crop yields since the 1950s, and increases in the use of fire for clearing fields. Some trees used by whitethroats have potential for restoring soil fertility.
- Improving habitat for whitethroats could have both agronomic and wider conservation benefits and provision of information that accommodates farmers' cultural and economic incentives could benefit both farmers and wildlife.
- This thesis has identified conservation benefits for farmland birds arising from the management of multifunctional farmland landscapes. A better understanding of farmers' motivation is likely to result in wider adoption of conservation management.

Acknowledgements

I thank my supervisors, Dick Morris and Jeremy Wilson for their support with this thesis. They have put up with my long periods of inactivity, interspersed with urgent demands for help. I also thank Nicholas Aebischer for advice, especially relating to statistical matters.

At Loddington I am grateful to John Szczur, without whose nest-finding abilities chapters 5 and 6 would be considerably poorer. Special thanks to Nigel Boatman for his support and numerous fruitful discussions, and to him and Sarah Boatman for putting up with my seasonal occupation of a part of their house, and my cooking of wildlife at unconventional times.

In Senegambia I thank Nfarmara Manneh and his family for their hospitality, and especially Buba Demba for introducing me to Mandinka ways and for rescuing me from numerous cultural faux pas. Thanks also to Ibraham Joof for acting as interpreter, and to Soulayman Jammeh for introducing me to the study area in the first place.

Not least, I thank the many farmers in Britain and in Senegambia for allowing me to walk all over their land and for sharing their knowledge with me.

Contents

Historical, biological and cultural background

The role of game management in the conservation of farmland passerines

Whitethroat habitat management

List of figures

Chapter 1.

Introduction

Agricultural changes in the second half of the twentieth century have had a substantial impact on farmland ecosystems with a widespread concurrent decline in biodiversity. Changes in biodiversity are well documented for bird species, many of which have declined dramatically during the period of agricultural intensification. Grey partridge *Perdix perdix*, lapwing *Vanellus vanellus*, turtle dove *Streptopelia turtur*, skylark *Alauda arvensis*, song thrush *Turdus philomelos*, tree sparrow *Passer montanus*, reed bunting *Embiriza schoeniclus* and corn bunting *Miliaria calandra* have been amongst the worst affected species (Gregory *et al.*, 2000). Similar declines in farmland species have been experienced across Europe, with 42% of declining species being affected by agricultural intensification (Tucker & Heath, 1994; Schifferli, 2000). Such severe declines have not occurred for species associated with other habitats.

Birds are valued by a substantial proportion of the U.K. population, with the Royal Society of the Protection of Birds (RSPB), the country's leading bird conservation organisation, having more than one million members. Bird abundance has become one of the U.K. Government's official 'quality of life' indicators, additional to social and economic indicators (Anon, 1999).

As different bird species have different ecological requirements, their populations are likely to be affected in different ways by changes in the agricultural environment. However, a number of factors have been identified as having widespread negative impacts on farmland bird populations. Economies of scale and increasing machinery size have encouraged enlargement of fields, reducing the area of hedges and other non-crop habitats that are used by birds (Barr *et al.*, 1994). Within fields, increasing use and efficacy of herbicides and insecticides have reduced food sources in the form of weed seeds and arable invertebrates (Potts, 1997). Simplification of crop rotations and changes in cultivation timing and methods have reduced the diversity and changed the nature of habitats available to birds throughout the year. For migratory species, wintering in sub-Saharan Africa, changes in farming practice there are also likely to influence winter survival of birds.

Farming systems throughout the world are subject to a wide range of influences, including environmental factors such as climate and soil type, and increasingly, global and national policies on agricultural trade. The latter set the boundaries for economic influences although local market forces, in turn influenced by cultural norms such as regional diet, are often strong. Like environmental and economic factors, cultural factors also influence the way farmland environments are managed by farmers, especially in relation to non-cropped components of these environments. For farmland birds, these various influences therefore have considerable impact. For migratory species, environmental, economic and cultural influences may operate several thousand kilometres from the breeding areas and yet be sufficient to determine breeding abundance. This complex process of interacting influences is illustrated in simplified form in figure 1.1. The thesis chapters addressing the various elements of this figure are also indicated.

A wide range of related environmental problems has occurred, concurrent with declines in farmland birds. Concern is increasing over wider environmental problems associated with agricultural intensification in both the breeding and wintering ranges of farmland birds. The sustainability and ethics of modern farming systems are being questioned (Pretty *et al.*, 2000). Because they are widely distributed, easily monitored and normally high in the food chain, birds have been considered as reliable indicators of such wider ecological degradation (Furness & Greenwood, 1993; Tucker, 1999).

In both European and sub-Saharan farming systems, changing economic circumstances, such as changes in subsidies for food production or export, local market forces and productivity of other local industries influence farmers' management of the farmland environment. However, socio-economic and cultural factors, including the attitudes, perceptions and interests of farmers, also play a major role in the management of farmland habitats and thereby the numbers of farmland birds. Production-linked incentives to European farmers encouraged the rapid development of agricultural equipment, cultivars and methods, and a "progressive" attitude to farming which became associated with large-scale "clean" and "tidy" farm landscapes with few habitats for birds and other wildlife (Nassauer & Westmacott, 1987). Other cultural factors, including those associated with recreational activities, operate independently of such incentives.

The research presented in this thesis investigates the interaction between farmers' interests and their management of farmland habitats, and assesses the response to that management in terms of bird numbers. It is intended to provide an improved understanding of the ecological and cultural aspects of the management of farmland as a habitat for birds, and to make recommendations for increased adoption of management

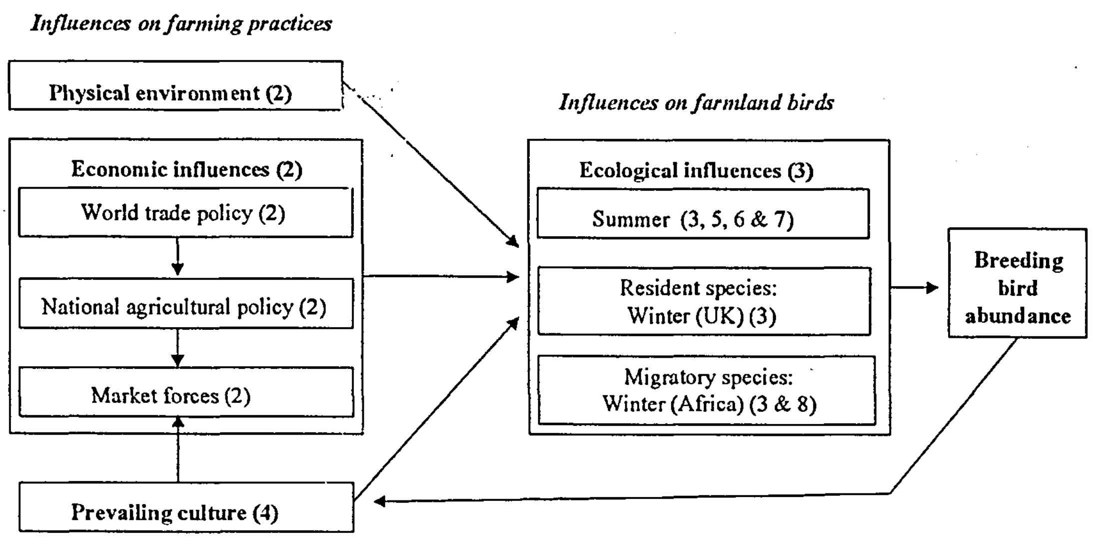

Figure 1.1. The relationship between influences on farming practices and influences on bird abundance on farmland. Chapter numbers in parentheses.

practices that benefit birds. Practical application to farmland bird conservation is a priority for this research.

While farmers are becoming increasingly interested in landscape and wildlife on farmland (Westmacott & Worthington, 1997; MacDonald & Johnson, 2000), a greater number of farmers is interested in management of game for shooting than in the conservation of other wildlife (MacDonald, 1984; MacDonald & Johnson, 2000). Conservation benefits of game management to passerines have never been formally documented. This issue forms the subject of part of this thesis.

A dramatic decline in grey partridge numbers in the 1960s prompted a long and intensive period of research into the ecology of this species on farmland (Potts, 1986). This long-term research has improved our understanding of arable ecosystems (Potts, 1991; Tucker, 1997) and indirectly influenced management of farmland for some other species, but the grey partridge itself, and many other species, are now present in very low numbers and continue to decline. This has been attributed to the failure of the UK government and EU authorities to recognise that "the only way forward appears to be a wholesale re-balancing of the CAP funding" (Potts, 2000). In 1992, "Agenda 2000" reform of the Common Agricultural Policy set the scene for such radical measures but politicians have been slow to develop appropriate "agri-environmental" measures (Potts, 2000).

Such a lack of political will is likely to reflect a widespread popular perception of farmland environments as inherently hostile to wildlife, and a reluctance amongst farmers to deviate from production-led policies. Popular values and the attitudes of farmers towards farmland species and habitats are cultural issues which are likely to have a major bearing on both agri-environmental policy at the national and international level, and on habitat management at the farm scale. "What we clearly need is a harmony between private investment and public investment ... for the benefit of everyone interested in [farmland] wildlife" (Potts, 2000).

The effectiveness of both private and public investment is dependent on the interactions between cultural, economic and environmental influences. These interactions have been poorly researched until very recently, but the need to understand farmers' motivation, including non-economic cultural values, is increasingly recognised as being central to the success of conservation management on farmland (Young *et al.*, 1995; Harrison *et al.*, 1998).

Because of its wide scope, the research presented in this thesis is interdisciplinary. It involves ecological research on farmland birds, but it also involves more exploratory research and the participation of farmers in improving mutual understanding of relevant issues.

Chapter 2 presents the historical background to farming practices in lowland England and the influences on these of changes in technology and economic and agricultural policy at national and global levels. The chapter covers farming practices and the influences on them in West Africa, as farmland in this region is an important wintering habitat for some European breeding birds. Chapter 3 describes the changes in bird numbers on farmland and the processes regulating bird populations, especially those determined by changes in farming methods. The cultural and socio-economic influences on the management of farmland are explored in chapter 4.

Chapters 5 - 8 describe my research into farmers' management strategies and their implications for bird conservation on farmland. Chapter 5 describes a study of farmland bird nesting success and breeding abundance in relation to the introduction of a game management system into an otherwise conventional farming system at Loddington (Leicestershire). Chapter 6 takes a closer look at nesting success and territory establishment in field boundaries, in relation to their management by farmers, with emphasis on one farmland bird species, the whitethroat *Sylvia communis*. Chapters 7 and 8 investigate farmers' motivation for the management of whitethroat habitat on farmland in both the species' breeding area (lowland England) and in its wintering area (Senegambia).

Practical application is a priority for the work presented in this thesis. The section on breeding passerines at Loddington provides information that can be used, as appropriate, to encourage or enhance existing wild game management practices to the benefit of nationally declining farmland passerines. The specific work on whitethroat habitat use and management could enable alternative incentives and management practices to be developed, with the collaboration of farmers, to benefit both whitethroats and farmers. Recommendations for such practical application and further research are made in chapter 9.

Historical, biological and cultural background: a review

Chapter 2 considers historical changes in agricultural practice in Britain, and in the West African wintering areas of some British-breeding farmland birds. Chapter 3 reviews the information currently available on the processes involved in the regulation of farmland bird populations, and the interaction of these processes with agricultural practice. Chapter 4 describes how socio-economic and cultural factors can influence the management of farmland habitats used by birds.

Chapter 2.

Historical changes in farming policy and practices

The distribution within Britain of both cultivated and wild plants on farmland is partly determined by climate and soil types. Several wild plant species are associated almost exclusively with arable cultivation and many with individual crops. Others are characteristic of undisturbed grassland. Changes in the distribution and abundance of these plant species are therefore closely related to those of farming methods and crop types within Britain. This, in turn, influences the abundance and distribution on the animals that are dependent on them. For example, corn buntings and yellowhammers are associated with cereal crops (Shrubb, 1997; Kyrkos *et al.*, 1998), and lapwings with spring-sown cereals which require light easily cultivated soils (Hudson *et al.*, 1994). Reed buntings are associated with oilseed rape crops (Burton *et al.*, 1999). The distribution of birds is also influenced directly by environmental factors such as altitude and climate. In the case of migratory birds, farming methods adopted in their West African wintering areas can also have a major impact.

Within Britain, barley (*Hordeum distichum*) is grown mainly on lighter soils than wheat (*Triticum aestivum*), while rye (*Secale cereale*) and oats (*Avena sativa*) can be grown on more acidic soils than either of these. Linseed (*Linum usitatissimum*) is amongst the crops which require the longer, warmer summers of southern Britain while others (e.g.

oilseed rape) can be grown further north. Higher rainfall in western than eastern Britain largely determines the eastern distribution of arable crops generally. Conditions can be managed to suit crops which might not otherwise be appropriate for a particular farm, but this demands additional expense and can only be justified when market prices are high. Crop prices therefore have some impact on crop distribution within Britain, with falling gross margins contributing to the contraction of a crop's range to areas where climate and soil type enable it to be grown at less expense. Non-biological factors also influence the distribution of crops.

It is not possible to consider recent changes in farmland landscape without some understanding of how the mid-twentieth century landscape came into being. The loss of the previously abundant supply of French wheat, resulting from the Napoleonic Wars at the start of The 19th, century concentrated political minds on home production of this and other food (Trevelyan, 1944). Such government support for crop production had implications for the farmland landscape, and for the wildlife associated with it. By 1846 the difficulties of food supply during the Napoleonic Wars were forgotten and massive expansion in urban manufacturing industries led to demands for cheaper food. Reduced living costs for workers meant reduced labour costs for industrialists, an increasingly powerful voice in British politics. Government support for British farming was reduced, but the momentum built up over the period of support took agriculture through another twenty-five yeas of prosperity.

Up until the mid 1870s enormous developments had taken place in farming practices. In this period of Victorian 'High Farming', rotational farming came into its own and the mixed farm became, not simply a collection of farm crops and livestock, but an integrated system, each crop being managed in line with the requirements of the others (Grigg, 1989). As cereals formed the most profitable part of the system these were the focus of the rotation. With scarcely any inputs from outside, the farm had to be self supporting. Despite the apparent desirability of growing continuous cereals in order to maximise profits this was not possible as it was necessary to alternate cereal crops with others in order to maintain soil nutrient status and reduce competition from other plants (Wrightson, 1888). While high prices ensured that cereals were widely grown throughout Britain, other crops within the rotation maintained the diversity of crops on the farm. This diversity was important to farmland wildlife, but it was, in part, to *control* unwanted competitive species that rotational systems were so widely adopted. For birds, this meant that a range of habitats was available within any individual's home range, increasing the suitablity of the farmland environment throughout the year.

2.1 Crop rotations

In the absence of herbicides, weeds had to be controlled by cultivation which essentially meant hoeing, either by hand or with horse drawn implements (Wrightson, 1888). At one time land was left in bare fallow once in each rotation, the ground being ploughed several times between January and August to destroy the seedlings of annual weeds and exhaust the nutrient reserves of perennials. Root crops such as turnips (*Brassica rapa)*, swedes (*B. napus*) and mangels (*Beta vulgaris*) could be grown at this stage in the rotation and were drilled far enough apart to allow effective hoeing between the rows. This could be repeated two or three times during the crop's growth. Root crops therefore served as a cleaning crop, removing weeds from the land in preparation for a cereal crop in the following year. Other crops such as kale (*Brassica napus*) and cabbages (*B. oleracea*) performed the same role, and root crops traditionally formed the start of the arable rotation. Farmyard manure was applied primarily to the root crops for which the need was greater, the residue providing nutrients for the following cereals.

The role of livestock on the farm was, in part, to provide manure for the more profitable cereals (Wrightson, 1888; Grigg, 1989). Sheep were widely kept in the 1870s and produced wool and mutton for sale off the farm and manure for use on the arable crops. On the thin, light chalk soils of southern England they provided the key to improving the land for cereal production. Sheep were 'folded' on root crops, confined to a section of the field by wattle hurdles made of hazel (*Corylus avellana*) available from local woodland managed for the purpose. Sheep were moved on to another section when the first was fully grazed. The diet of roots was supplemented by the only external inputs into the rotational system at that time, cotton cake. This was a byproduct of the textile industry, imported in large quantities from Egypt and India and was valued for the quality of manure it produced as much as for its feeding value. As well as forming part of the cleaning stage of the rotation sheep therefore helped to recycle nutrients and, although removing some from the system in the form of wool and mutton, contributed to nutrient supply through the feeding of cotton cake. Cereal yields had also improved considerably since the early nineteenth century, in fact by 50% between 1830 and 1880 (Grigg, 1989).

Once the roots had been grazed the land was ploughed and a cereal crop was sown. In most rotations this was barley for sale off the farm or for use on the farm as animal feed. Oats were also grown as a feed for both horses and cattle. Where appropriate, the cereal crop was often undersown with the following crop in the rotation so that this was established when the cereal crop was harvested. This third stage in the rotation was intended to improve soil fertility, provide feed for livestock, and like the root crop, control weeds and return organic matter to the soil. Its fertility-improving role was due to the use of leguminous nitrogen fixing crops such as clover (*Trifolium spp.*), sainfoin (*Onobrychis sativa*), lucerne (*Medicago sativa*), peas (*Pisum sativum*) or beans (*Phaseolus vulgaris*).

Another cereal crop, normally wheat, was sown in the spring. This was harvested between August and October and the land ploughed and harrowed in preparation for the following root crop and the start of another rotation. This system improved the fertility of many soils, particularly on the light soils of East Anglia and the chalk downs.

Falling prices of farm products, especially cereals in the 1880s led to abandonment of rigid rotations in some areas and to changes in others (Grigg, 1989). The first blow to the system came with the importation of cheap wheat from the newly ploughed American prairies (Grigg, 1989). Wages of industrial workers rose, farm labourers moved to the towns, and farmers found labour costs rising while their income fell. The resulting reduction in agricultural activity changed the farmland landscape. Although little quantitative information is available on farmland wildlife during this period, such changes would have had considerable implications for many species. Similar political, social and economic changes occurred in West Africa, where they would have had an impact on European-breeding birds during the winter.

2.2 Early trade with West Africa

Since the first links between Europe and West Africa were established by the Portuguese in the fifteenth century, the two regions were involved in trade which was to have considerable implications for agriculture in both regions. West Africa was also, and continues to be, an important wintering area for many migratory birds, some of which (e.g whitethroat) use farmland habitats in both continents.

South of the Sahara, the region is divided into geographical belts running west-east. These comprise the Sahel, which is largely open savanna with 200-700mm annual rainfall, the Sudan with more than 700mm rainfall and more wooded savanna, and a southern belt of former forest, merging with rainforest (now almost completely cleared) towards the southern coast. The rivers Senegal and Gambia are important for both agriculture and birds in that they support intensive rice (*Oryza sativa*) growing and a diversity of irrigated dryland crops, and provide permanently vegetated areas. These are rich in the insects and fruit which form the diet of migratory birds, both in winter, and on migration. Away from the rivers, rainfed crops include groundnut (*Arachis hypogea and A. subterranea*), which has long been grown both as a cash and subsistence crop, and millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*), which are mainly subsistence crops. Livestock, including cattle, sheep and goats, also play an important part, with Zebu cattle being the focus of transhumance systems in the north, and trypanosomiasis-resistent Ndama cattle being kept by sedentary farmers in the south.

With the slave trade abolished, the 1880s saw a revised interest in the role of West Africa in the wealth of European countries. Trade relations with coastal wholesalers of agricultural products had become strained (Hopkins, 1990). The period saw rapid invasion of the region by Europeans, with the British and French respectively subsequently developing a groundnut industry in Nigeria and expanding the existing one in Senegal. Developments were fastest in Senegal as, whereas Nigeria required the establishment of a rail network, the port of Dakar provided convenient access to the groundnut growing region (Hart, 1982). The development of the steamship provided a boost to this trade (Hopkins, 1990).

Neighbouring regions were also colonised to provide labour for the industry and food for the labourers, providing a new market economy in livestock for pastoralists north of the Senegal River for example (Cheikh, 1990). The groundnut industry also took male labour from formerly thriving rice growing regions on the rivers Senegal and Gambia, leaving women to concentrate on rice as a subsistence crop and defining gender roles that have persisted in Mandinka culture to the present (Shroeder & Watts, 1991). The groundnut growing also replaced other established agricultural systems for the production of crops for subsistence and small-scale trade. Vast areas of land were cleared of trees, and fallow land, seen as unproductive by the Europeans, was brought into production. As the majority of bird species, both sedentary and migratory, are associated with trees in woodland savanna or closed canopy woodland, this clearance would have had severe implications for many species.

2.3 Agricultural depression

While the agricultural area in West Africa expanded, the first four decades of the 20th century were a period of deterioration in British farming as a result of rising labour costs and competition with imported food. Much of the arable land was returned to grass which provided a modest income from low input meat production. The corn growing area contracted mainly to the east and south east where the climate best suited it and where mixed farming could continue to be practised. But even in East Anglia the area under cereals declined, resulting in a smaller area of roots, fewer sheep and poorer soils. An increase in beef cattle barely compensated for the loss of sheep from the land. The west with its higher rainfall became largely a grass growing region with some cereals and root crops being grown as feed for livestock (Grigg, 1989).

Where it could still be practised, rotational arable farming continued around the turn of the century in a more low key way than previously. Although the methods were similar, this was not the dynamic farming industry that had gone before. Many farmers went out of business towards the end of the 19th century and large estates were sold to wealthy businessmen who had made their money in industry (Tapper, 1992). Landowners had long had uses for their land other than those of agriculture, and the management of many estates was adapted to accommodate game shooting interests. Now, with an unprofitable farming industry, and new estate owners with income from other sources, game management became the primary activity for many estates. The needs of partridges influenced the farm cropping, hedges and other cover were managed to provide optimum habitat, and teams of gamekeepers controlled predators throughout the year and fed gamebirds through the winter. Hunting interests also influenced the farmland landscape through the management of hedges and planting of small farm woods (Rackham, 1986). These cultural influences therefore had considerable implications for farmland landscapes and wildlife.

There continued to be agricultural developments though, particularly in the development of farm machinery which, in the light of rising labour costs, gradually became more attractive. Self binding reaping machines reduced labour reguirements at harvest while portable threshing machines allowed ricks to be built in the field or nearby, instead of being carted to the farm for eventual threshing there.

2.4 Fertilisers and livestock

The development and import of artificial fertilisers helped to provide an escape from the established rotation in some areas. Guano, the accumulated droppings of sea birds, was imported from Peru during the 19th century but, when supplies were exhausted, an alternative supply of phosphorus had to found. Basic slag, a byproduct from steel ores became available and widely used in the 1880s and contained lime as well as 20-40% phosphate (Wright, 1906). Bones were later used, dissolved in sulphuric acid, to make the fertiliser, 'Superphosphate' although mineral phosphates imported from Florida and North Africa superseded bones for this purpose. Cereal prices did not normally warrant application of these chemical fertilisers and attention was mainly directed at higher value vegetable crops at this time.

Although most fertilisers were phosphate based, nitrogen was also sometimes applied in the form of ammonium sulphate, a byproduct of the gas industry (Wright, 1906). This, with Superphosphate and Basic Slag, formed the earliest chemical fertilisers and made it possible for farmers in eastern England to adopt root crops which were sold off the farm as cash crops instead of being grazed. Sugar beet (*Beta vulgaris*) and potatoes (*Solanum tuberosum*) entered the arable rotation in eastern England in the early part of this century. The development of the Haber-Bosch synthesis of ammonia in Germany meant that farmers no longer had to incorporate livestock in the arable rotation for reasons of nutrient conservation, so beginning a geographical polarisation of farming, with arable in the south and east, and livestock in the north and west.

In much of southern England, and particularly on the chalk downs, the thin calcareous soils were particularly well suited to growing high quality malting barley for the brewing industry. In some areas, fodder roots maintained their place in the rotation. The alternative in areas where sugar beet or potatoes could not easily be grown was bare fallow, an unproductive option albeit well suited to the weed-clearing role.

Livestock carrying capacity on the farm could be increased by providing an extra forage crop in the form of a catch crop between the previous cereals harvested in the early autumn and the spring-sown roots. Catch crops of this sort were mainly a southern practice as only here was the summer long enough to allow an early harvest and the winters mild enough to permit growth of the catch crop. Crop diversity was therefore high, especially on mixed farms, in the early twentieth century.

2.5 Grass leys

Once the wheat was harvested the following crop was allowed to grow on. This crop, as mentioned earlier, was either of grass, a legume, or a mixture of the two and was either grazed or cut for hay during the course of the following year. As well as contributing to crop diversity at the farm scale, such leys were themselves botanically diverse.

Legumes such as these increased the nitrogen content of soils while grass and legume mixes also produced a turf which, when ploughed in for the following crop, increased the organic matter. Being shallow rooted and requiring a gradual release of nutrients from the soil, barley was a good crop to follow the grass stage of the rotation.

2.6 Early pesticides

The use of copper sulphate solution to treat seeds to prevent development of fungal diseases in the growing plant was an early use of a chemical against natural hazards to the crop. Copper sulphate was also used as 'Bordeaux Mixture'. Although originally used as a fungicide on vines, in Britain it was widely used in a similar role on cereal crops (Wright, 1906). As well as being an early fungicide, copper sulphate was also adopted as the first herbicide, used as a 3-5% solution to control charlock (*Sinapis arvensis*) and wild radish (*Raphanus raphanistrum*) in cereals. Weeds unaffected by copper sulphate continued to flourish despite the efforts of farmers in threshing and other activities. Corn cockle (*Agrostemma githago*) was a common cereal weed in the early 20th century whose poisonous seeds were similar in size to cereal grains and therefore difficult to remove.

2.7 Dairying

The technical position of farming remained much the same well into the 1930s in most areas although machines were increasingly used to do the work previously carried out by hand and horse power. During the whole of this half-century corn prices failed to recover and sheep were increasingly abandoned in the face of foreign competition. Against this gloomy background, however, dairying, was developing to meet an increasing demand for fresh milk. Throughout almost all of the 19th century milk had been supplied to the expanding urban population from small dairy units located within the cities and importing feed from the country. This situation changed with improvements in the production, hygiene and transport of milk in rural areas.

Maintaining a dairy herd was labour intensive. Kale was grown in the roots stage of the arable rotation and cut daily for carting to the dairy as feed. Milking was all done by hand and milk had to be carted to the local railway station twice each day. But it was profitable at a time when most aspects of farming were not and many farmers increased the number of dairy cows they held so as to take advantage of the new demand for liquid milk. In Wiltshire particularly, the 1920s saw many arable farms introducing dairy herds as a major component of their rotation, prolonging the grass ley stage to meet the grazing requirements and provide hay. Those farms with meadows close to the farm buildings made increasing use of these for hay and some continued to be managed as water meadows. This in itself provided employment throughout the year, as the meadows were flooded each spring and the water levels carefully maintained to allow nutrients to be deposited on the land. 'Carriers' and 'drains' were created and maintained across the meadows to carry the water from and to the rivers. Water meadows increased the diversity of habitats within farms.

2.8 Post war agriculture

The period during, and immediately following the Second World War saw dramatic changes in agricultural policy. County and District War Agricultural Committees ordered large scale ploughing of grass and administered rationing of feed and fertilisers and provision of farm machinery. The arable land turned to grass earlier in the century had been maintained with little knowledge of grassland management but farmers were encouraged by the stimulus of government support and became receptive to new ideas. The Agricultural Development Act of 1946 extended the plough up policy to land of more than three years in grass and, more significantly, in 1947 The Agriculture Act guaranteed prices and markets, setting the scene for a stable industry and marking a watershed in British agricultural history.

When the cereal market collapsed in the 1930s diversification had saved many British farmers from ruin while their more specialised cereal-growing American and Canadian counterparts were less fortunate. With the war over and subsidies available for livestock as well as cereals, mixed farming continued and developed in many areas. Even before the war the high labour costs and low income which had removed sheep and roots from most arable systems had stimulated the search for an alternative. Grass was to prove the key to this; not the unproductive sward which had resulted from the abandonment of arable land but a carefully managed system designed to improve and maintain soil condition (Stapledon & Davies, 1941). The structure and botanical composition of these swards is likely to have influenced the birds and other wildlife using them, but modificatins to the crop rotation as a whole are likely to have had an even greater impact.

The new system was originally developed in Wales by Robert Elliot (1898). Elliot's method was to change the roots-corn-grass-corn rotation to corn-roots-corn-roots followed by a four-year grass ley. With little fertiliser and little oilseed feed the impoverished soil was improved by this system because the ley included a range of deep-rooted grasses, legumes and other herbs, all of which contributed minerals and organic matter to the soil. The initial failure of Elliot's system to be adopted may have stemmed partly from the attention paid by those interested in it to the seed mixes he advocated rather than the principle of the *system* itself.

Cultivated varieties of ryegrass (*Lolium perene*), cocksfoot (*Dactylis glomerata*), timothy (*Phleum pratense*) and various clovers improved yields of hay from pastures and boosted milk and beef production. Many water meadows were drained and ploughed up during the 1940s and '50s and reseeded with more fertiliser responsive grass mixtures. It was no longer economically viable to manage water meadows and hay was difficult to harvest mechanically on the ridges and furrows. The grass component of many pastures and leys was eventually reduced to just one or two species, selected to respond to fertiliser application. The government had tried to encourage farmers to change from hay to silage during the war and, although it was slow to be adopted (Hanley, 1949), its use was widespread within twenty years. Cereals were also increasingly used as feed, being mixed with minerals to provide a balanced and nutritious diet designed to meet the requirements of the dairy cow.

2.9 Silage

Many dairy herds calve in the autumn. Milk production depends on the quantity and quality of the feed. To produce more milk, a cow needs extra feed in the form of high-energy concentrates, usually provided at milking. However, silage, the preserved and stored grass grown on the farm, can also be used. The higher the quality of grass used for grazing or silage, the less the need for expensive, bought in concentrates (Russell & Slater, 1985). In many areas, the first cut of silage can now be made in mid-May, and is often followed by another two or even three cuts if grass growth allows it.

Use of inorganic fertilisers, especially nitrogen, increased in the 1970s. Levels of fertiliser application are known to influence botanical diversity of meadows, even at relatively low rates (Kirkham *et al.*, 1992) and high rates eliminate all but the most vigorous species. The area of low input, permanent pasture dropped by more than 90% between 1930 and 1980 as the area and level of intensification of grass ley and arable crop management increased (Fuller, 1987).

Dairy herd size on farms increased. Meat production also became increasingly intensive. Although the number of sheep or beef cattle present at any one time in Britain had not increased substantially, animals were being slaughtered at a very much earlier age with the result that turnover was considerably increased. An unfortunate consequence of bigger dairy herds was the increase in the amount of manure, now in the form of liquid slurry rather than farmyard manure. Tight controls on storage were eventually imposed to reduce pollution incidents in rivers and streams.

These changes marked the end of low input management of grassland, with the conservation value such a habitat had for birds and other wildlife. More intensive management of grassland with homogeneous structure, has substantial deleterious effects on bird species such as lapwing (Baines, 1990), corncrake (Green & Williams, 1997), and passerines such as skylark (Wakeham-Dawson & Smith, 2000; Perkins *et al.*, 2000).

2.10 Advances in cereal farming

The massive investment in breed improvement in the national dairy herd was paralleled by similar activity in the arable crops, particularly cereals. Increased yields were also aimed for, plants which were most able to take advantage of the increasingly applied fertilisers being selected. The use of more nitrogen and the weight of heavier ears led to weakened straw, and resistence to flattening of the crop ('lodging') became another target (Hanley, 1949). Short, stiff-strawed varieties were therefore bred. These could be easily harvested using the new combine harvesters of the early 1960s and, with little demand for thatching straw and with eastern farms increasingly specialising in cereals, the reduced amount of straw for disposal was an additional advantage. Scandinavian varieties of barley were used to improve British strains so that these would ripen earlier and could be grown further north, pushing into the territory vacated by oats as the decline in the use of horses made this crop redundant. Barley was almost exclusively spring-sown and the development of autumn-sown varieties did not really become established until the 1970s, bringing the ripening of barley further forward and spreading the demand for labour on specialist cereal farms.

The machinery associated with these changes in cereal production developed to keep pace with the greater cereal production. Large combine harvesters speeded up the harvest, as did the installation of grain dryers. Increasingly powerful tractors helped farmers complete their ploughing earlier, enabling them to grow the higher-yielding autumn-sown varieties on a wider scale. This move to autumn-sown crops was a major reason for the substantial decline in the area of undersown and winter stubbles. Prior to the widespread use of herbicides which killed seeding weeds, stubbles provided feeding areas for finches and buntings through the winter. Changes from spring- to autumn-sowing are also thought to have contributed to declines in many formerly common spring-germinating arable plants such as corn marigold (*Chrysanthemum segetum*) and night-flowering catchfly (*Silene noctiflora*) (Wilson, 1994). More recently, botanical composition of arable crops continued to be influenced by cultivation methods, with the adoption of minimal tillage since the 1970s encouraging grass weeds (Attwood, 1985).

The post war period saw increasing geographical polarisation in crop production, with the loss of livestock from eastern farms (Coppock, 1971). Meadows and other pasture in the east were converted to arable and the habitat diversity on farmland declined. Grassland plant communities which survived the plough were also affected. In the absence of farm livestock, chalk grassland, which had survived into the 1950s because it was too steep to plough, became invaded by scrub. This process was accelerated by the introduction of myxomatosis in 1954, which depleted rabbit numbers, allowing elder (*Sambucus nigra*), blackthorn (*Prunus spinosa*), privet (*Ligustrum vulgare*) and other shrub species to spread into grass swards. With a decline in the area of botanically diverse grassland came a decline in the insect communities dependent on it (Green, 1990). Newbold (1989) reported losses or serious damage to 80% of British calcareous grassland between 1949 and 1984 and the loss of diverse grassland ecosystems to arable crops and changes in grazing regimes has continued since then.

2.11 Chemical inputs

The development of increasingly productive crop varieties was simultaneous with, and partially dependent on, the development of chemical inputs to the arable system which changed as a result. Fertilisers were cheap and machinery made the previously labour intensive cultivations considerably easier but, in addition, some cultivations were becoming redundant. The early 1940s had seen the use of the first chemical control of plant and insect pests. The discovery of the insecticidal properties of DDT and other organochlorines was to lead to the establishment of a whole new method of controlling pests. These chemicals were thought to be practically non toxic to mammals when first developed and therefore safe to use, but their impact on a number of carnivorous mammals and birds eventually became apparent as numbers of raptors, otters (*Lutra lutra*) and fish-eating birds declined (Cooke *et al.*, 1982). These organochlorines were replaced by organophosphates and eventually banned as equally effective and less obviously harmful insecticides were developed. The ecological impact of organochlorines, highlighted by Rachel Carson's (1962) now classic book 'Silent Spring' was largely responsible for the development of conservation movement, changing popular attitudes from one of production at any cost, to greater concern for the environment.

Weeds could also be controlled using chemicals with early herbicides comprising sulphuric acid, DNOC (dinitro-orthocresol), MCPA (methylchlorophenoxyacetic acid) and 2,4-D (2,4-dichlorophenoxyacetic acid) (Woodford, 1960). The new translocated (systemic) herbicides would kill both annuals and perennials and were more effective than copper sulphate and sulphuric acid for controlling such species as corn buttercup (*Ranunculus arvensis*), shepherds needle (*Scandex pecten-veneris*) and white charlock (*Sinapis alba*) (Woodford, 1960). Residual herbicides such as monuron and simazine were later developed to control seedlings of other weeds as they germinated. By the 1960s pesticides were established as a major tool in cereal farming.

Now the number of active ingredients and their spectrum of activity means that most weeds can be controlled with herbicides at least somewhere in the arable rotation. However, routine reliance on a small number of herbicides has resulted in the development of resistant populations of some species. The first and most important of these has been black grass (*Alopecurus myosuroides*), strains of which have developed resistance to the herbicides used against it (Cussans & Marshall, 1990).

Wilson (1994) reported considerable declines in the arable flora since surveys in the 1930-1960 period (Wilson, 1994). Several of the rarest species now no longer occur in arable habitats, but for others, the most suitable areas remain the calcareous and sandy soils of south and east England (Wilson, 1994). This is especially the case for spring-germinating species which are largely dependent on spring cultivation which is confined to these soil types. Similar declines in the arable flora have been reported from Germany (Agra Europe, 1991) and Denmark (Andreasen *et al.*, 1996). Increasing use of fertilisers and efficacy of herbicides were the main causes of the loss of these arable plants.

Originally applied only to arable crops whose value justified the expense involved, herbicides eventually played a role in controlling weeds in grassland where high stocking densities were now damaging the turf and allowing unproductive plants into the sward. Here, weeds such as yellow rattle (*Rhinanthus minor*) and lesser spearwort (*Ranunculus flammula*) were also gradually eradicated by drainage and applying fertilisers that favoured the more vigorous grasses (Green, 1990). Large areas of grassland in northern Europe have been drained for conversion to arable crop production since the 1940s, but remaining wet grassland habitats have also been severely affected by drainage of adjacent arable land (Mountford & Sheail, 1984; Williams & Bowers, 1987).

The routine adoption of herbicides, with more fertiliser and the switch to autumn cultivation, reduced the populations of many arable weed species, some to the point of extreme national rarity. The increased use of nitrogen fertiliser was equally responsible as herbicides for the demise of many plant species. Between 1943 and 1988, average amounts of nitrogen applied to arable crops increased by 600% (Wilson, 1994). In addition, many of the insecticides developed to control pests such as aphids were not target-specific, so a wide range of insects, including aphid predators and the foods of farmland birds, were killed. Densities of many of the invertebrates eaten by birds declined because their food plants were eliminated or reduced in numbers (Ewald & Aebischer, 1999).

The wide array of pesticides, the availability of fertilisers and the rising price of cereals made grass leys less attractive as a means of controlling weeds and insect pests or maintaining soil fertility and encouraged farmers to abandon their leys in favour of more profitable continuous cereal cropping. The diversity of crops on any one farm decreased considerably with the original rotation being reduced to a series of years in cereals followed by a single break crop. The introduction of a wider range of effective fungicides in the 1970s and the continuing high price of cereals, coupled with availability of high yielding varieties, made even this break financially unattractive to some and continuous cereal cropping was adopted on many farms.

2.12 Field boundaries

As larger and more sophisticated machinery entered the market farmers found that the size of their fields restricted efficient use of their new machines. Farms were amalgamated and hedges were removed in order to increase field size. This continued into the 1980s and '90s. Barr *et al.* (1994) reported a 1.7% annual rate of hedgerow loss in the 1984-1990 period, but this had reduced to 0.8% pa in the 1990-1993 period when the rate of hedge planting had increased from 0.4% pa to 1% pa. In the regions studied by Westmacott and Worthington (1997) 16,280 km of hedges were removed in the 1983-1994 period, compared with 3,225 km planted. Hedge removal had been greater in the period up to 1983. Most recently changes have been more evident in the structure of hedges, resulting from abandonment, than in their removal. Barr *et al.* (1994) reported annual rates of 5.2% of hedges abandoned, compared with 1.3% restored. However, Westmacott and Worthington (1997) found an 'improvement' in hedge 'quality' in some areas. As with many landscape assessments, perceptions of 'quality' are likely to influence reported changes. Most recently, the decline in hedge loss has been halted, new plantings (encouraged by agri-environment incentives) are reversing this decline and hedge restoration largely counteracts degeneration (Haines-Young *et al.*, 2000).

Field boundaries were formerly maintained as nesting habitat for grey partridges which require an abundance of perennial grasses in the hedge base (Rands, 1987 & 1988). However, while shooting interests amongst farmers were maintained, there was a substantial decline in the management of wild gamebirds through the 20th century

(Tapper, 1992). This was a result of the loss of gamekeepers in two world wars, changing cultural values and increasing labour costs. However, the development of the scale of the arable industry, with reduced crop diversity and loss of field boundaries, and the loss of the arable invertebrates as chick food following the widespread use of pesticides, all made the arable landscape unsuitable for partridges. Instead, farmers with shooting interests turned their attention to reared pheasants (*Phasianus colchicus*) for which there was not the need for the management of breeding habitats. With this incentive gone, the herbaceous vegetation in field boundaries was destroyed by fertiliser and pesticide drift and ploughing into the hedge base (Boatman, 1989). As discussed in chapter 6, the loss of this field boundary vegetation is likely to have influenced the breeding abundance of some farmland birds. In particular, it is likely to have limited the recovery of the whitethroat population, following the population crash accompanying drought in its West African winter range in 1969 (Winstanley *et al.*, 1974).

2.13 West African agriculture

Agricultural changes in West Africa during the 20th century had a considerable impact on the habitats used by migratory birds in the northern winter, especially whitethroats which are associated with farmland habitats in Senegambia. Vegetable oil production in the form of groundnuts had increased dramatically through the first part of the 20th century but subsequently experienced equally dramatic declines. The industry had brought economic wealth to Senegal, but at a price. Disregard for the nature of the region's soils and indigenous methods of cultivation, and increased pressure on the land resulting from the replacement of food crop cultivation by groundnuts, led to severe soil degradation (Kane *et al.*, 1990). In particular, the adoption of continuous cultivation, rather than fallow systems, caused considerable soil erosion and a decline in soil fertility so that yields of both cash and food crops declined. Lower than average rainfall from the 1970s added to the problem, especially on degraded soils. Groundnut yields in The Gambia, for example, declined by 1.7% pa, and cultivated area by 0.6% pa, between 1974 and 1984 (Braun *et al.*, 1990).

The loss of woody vegetation from this region has been associated with increased erosion and incidence of dust storms towards the end of the dry season, with dust storm frequency being strongly correlated with average annual rainfall over the previous three years (Middleton, 1985). Prospero and Nees (1986) reported an increasing incidence of Sahelian dust reaching Barbados since the 1960s, and revealed that this was correlated with rainfall in sub-Saharan Africa.

Subsidised production of oilseeds in Europe (see below), and dumping of surplus production on the international market, undermined the market for groundnuts from Africa (Gardner, 1996). At the same time, West African farmers had to contend with substantial increases in the price of fertiliser and groundnut seed associated with trade liberalization, often fueled by Structural Adjustment Programmes. Such changes resulted in withdrawal of labour from dryland farming systems, a substantial decline in production, and in increases in costs of subsistence cropping (Schroeder, 1997). The resulting increased use of fire to clear land of weeds and shrubs at minimum cost has had deleterious consequences for a wide range of farmland species, including migratory birds.

2.14 Global agricultural policy

Britain entered the EEC in 1973 and with it the Common Agricultural Policy (CAP). In response to government support and new technology, the cereal area increased further and European wheat yields increased by more than 60% in the 1965-1980 period (Gardner, 1996). New crops qualifying for subsidies appeared. Oilseed rape increased considerably, especially in the 1980s. Although vegetable oil was the main product, a byproduct, rape-seed meal, was used as animal feed. New varieties contained lower levels of the toxins that had prevented more large-scale use as feed, although this made the growing crop more palatable to deer, hares and rabbits.

Flax crops qualify for subsidies even when grown on land which is not eligible for arable area payments, and these subsidies exceed the value of payments for protection of grassland habitats so that some areas of botanically diverse grassland have been destroyed. Previously uncultivated land is also currently being lost to potato production, as disease-free land is often required for this crop (CPRE, 1999).

European milk and cereal production increased, costing the EEC expenditure in the form of subsidies and it was this financial burden, rather than the surpluses themselves which eventually led to imposition of milk quotas and the introduction of a levy for cereals in order to limit production. Under the CAP, subsidies were paid to producers or users, levies imposed on imports and subsidies (restitutions) paid on exports.

During the 1990s, considerable changes to world trade in, and support for agricultural products occurred. The last round of GATT negotiations, the Uruguay Round, culminated in 1993 with agreements to cut export subsidies by 36%, subsidized export volume by 21%, and support for domestic production by 20%. At around the same time, the 1992 Earth summit in Rio de Janeiro identified a need to raise economic prosperity of rural communities, and improve environmental quality and sustainable exploitation of resources ('Agenda 21'). The GATT was replaced in 1995 by the World Trade Organization (WTO) which is committed to further liberalization of world trade in agricultural and other products, and a ban on restrictions on their international trade for environmental reasons. Counter to the Earth Summit, this has placed the emphasis on market pressures, rather than regulation, for environmentally sustainable use of natural resources.

Reform of the CAP (the MacSharry reforms) in 1992 involved change from support for the market to support for farmers, an aim to reduce production of cereals and other products, and reduced support for exports. This latter was intended to increase, or at least prevent a decline in world prices. Set-aside was introduced to reduce arable crop production and involved taking a defined proportion of arable land out of production each year in exchange for continued arable payment of productions subsidies (arable area payments). The proportion of arable land taken out of production in this way has varied between 5% and 15%. Although intended as a production control measure, set-aside has to some extent since become a mechanism for providing environmental benefits. In addition, schemes intended to improve the agricultural environment (agri-environment schemes) became mandatory for all member states in 1992, including the identification of five-year zonal programmes for regional environmental improvement (EC/2078/92).

In the U.K., agri-environmental schemes include the Countryside Stewardship Scheme, Environmentally Sensitive Areas, Nitrate Sensitive Areas (subsequently Nitrate Vulnerable Zones), and a pilot Arable Stewardship Scheme, all of which provide for environmentally beneficial management of cropped and uncropped habitats within the arable landscape. Each scheme is intended to improve environmental quality, including the provision of wildlife habitats and landscape and the reduction of pollution of terrestrial and aquatic habitats. Although intended as a production limitation exercise, set-aside also provided some means of improving farmland habitats through provision of crops designed to meet the requirements of farmland wildlife (the Wild Bird Cover option). Additional measures to reduce pollution and degradation of farmland environment included Codes of Good Agricultural Practice (COGAPS) and Local Environmental Risk Assessments for Pesticides (LERAPS) (MAFF, 1999).

Following a further stage of reform (Agenda 2000), the various objectives for reform of European agricultural systems have been combined in the Rural Development Regulation (EC/1259/99), including in England, the Rural Enterprise Scheme. Production-linked payments are being diverted to these schemes through the process known as modulation. For example, cereal intervention payments were cut by 15% for 2000/2001, with further subsequent cuts, and money is diverted to area payments and agri-environment schemes, early retirement of farmers, and support for farmers in Less Favoured Areas (LFAs).

While these changes will inevitably have consequences for the economic and environmental status of rural communities in Europe, changes in the world prices of primary products will also have considerable impact on rural communities and their environment in liberalized economies such as those of West Africa. Here, farmers are not insulated from the world market by state intervention, and the impact on them can be more sudden and more severe. The prices of vegetable oils and coarse grains (including groundnut, millet and sorghum) are predicted to increase (Madeley, 1996), increasing the cost of imported food, but making farming of rainfed crops in Senegal and neighbouring countries more viable. The consequences of this on the farmland environment depend on whether a long- or short-term view is taken. Short-term maximization of economic returns could lead to further degradation of soils and vegetation. Alternatively, such changes could increase the labour-force involved in cultivating these crops, reducing the use of fire for clearing arable ground.

In Europe, the switch from production-linked payments to those for sustainable resource use provides greater opportunities than those available in West Africa for the development of rural resource use systems that are mulitfunctional and sustainable, with social and environmental benefits, rather than simply being related to agricultural production. Economic support is increasingly being channeled towards diversification of resource use on farmland and integration of non-agricultural enterprises into farming systems. Farming practice everywhere is subject to development and change, and change in habitat type and distribution is probably inevitable, but not necessarily always deleterious in terms of wildlife conservation.

2.15 Synthesis

The aim of this chapter has been to describe the historical and geographical context within which wildlife species have been influenced by the management of agricultural land. While the history of agricultural development in Britain has been well recorded (e.g. Grigg, 1989), the implications for wildlife on farmland have been poorly documented and the simultaneous changes in crop production in West Africa have not previously been considered in relation to breeding abundance of migratory bird species. As many British-breeding birds use West African farmland habitats in winter, an understanding of these issues is essential to the development of bird conservation policy. There are important differences between the two regions in terms of production potential, environmental risk, cultural values of farmers, and state support for production and environmental management.

Little quantitative information is available on abundance of farmland wildlife prior to the mid twentieth century, but it is possible to suggest impacts of historical agricultural practice that may have occurred, based on current knowledge of agricultural ecosystems. For example international trade in the late nineteenth and early twentieth centuries resulted in an expansion of cash crop production in West Africa and an abandonment of intensive crop production in Britain. While migratory species may have benefited from the resulting low-input farming systems in their breeding range, degradation of wintering areas is likely to have been detrimental.

During the second half of the twentieth century we have a much better understanding of the impact of agricultural practices. This chapter has identified a wide range of practices that may influence farmland wildlife. For example, the British arable flora has been influenced by grain cleaning technology, herbicide use, and cultivation methods and timing. Similar influences on bird populations are examined further in chapter 3.

The use of broad-spectrum pesticides and the loss of landscape features such as hedges in the 1960s and '70s have increased popular awareness of environmental problems on farmland. The consequent expression of cultural values that support wildlife conservation has created political pressure for changes in agricultural policy. Cultural influences such as the development of game shoots as an expression of social status and identity can influence farming systems and are therefore likely to influence birds on farmland. This argument is developed in chapter 4.

Chapter 3.

Population change and regulation in farmland birds

Numbers of breeding birds have been monitored in Britain since 1962 when the BTO established the Common Birds Census (CBC) (Marchant *et al.*, 1990). More recently, the Breeding Birds Survey (BBS) was introduced in 1994 in order to provide a more systematic and geographically representative coverage for the monitoring of bird abundance in Britain. Both CBC and BBS have been conducted by a network of volunteers, co-ordinated by the BTO. Prior to the 1960s, little information was available on changes in breeding numbers of birds of farmland, or any other habitats, although county avifaunas and bird reports provide some information. For the grey partridge, bag records from 12 estates in southeast England suggest declines in numbers through the 1930s, '40s and '50s (Potts, 1986; Tapper, 1992). Because of its value as a gamebird, this species has also been the subject of March pair counts and these also suggest a sustained decline since the early 1950s (Potts, 1986).

3.1 Changes in bird numbers

Other species using farmland habitats are known to have declined before CBC monitoring began. O'Connor & Shrubb (1986) report the decline in Wryneck (*Jynx* *torquilla*) numbers documented by Peal (1968). For this species, conversion of established pasture, rich in ants, to arable is suggested as contributing to the decline in numbers through the 1940s and '50s, although a decline was already occurring before then, probably due to changes in structure of grassland feeding sites associated with abandonment. Documented declines in wheatears (*Oenanthe oenanthe*) during the 1940s are attributed to the ploughing of downland and its conversion to arable production (O'Connor & Shrubb, 1986), while whinchats (*Saxicola rubetra*) increased in the 1920s and '30s as the area of neglected grassland expanded (O'Connor & Shrubb, 1986). Redshanks (*Tringa totanus*) are known to have declined early in the 19th century as meadows were drained, and increased again in the agricultural depression of the 1880s as management of these meadows was abandoned (O'Connor & Shrubb, 1986). Barn owls (*Tyto alba*) also benefited from the increasing area of rough grassland during this period (Holloway, 1996).

The abundance of weeds associated with relatively unmanaged agricultural land in the late 19th and early 20th centuries benefited seed-eaters such as goldfinch (*Carduelis carduelis*) and linnet (*Carduelis cannabina*) (Holloway, 1996). For tree sparrow Summers-Smith (1989) provides evidence of a dramatic increase in numbers through the 1950s and early '60s. This period was followed by a sustained decline in numbers through the 1960s, 70s and 80s, as recorded by the CBC. Corn buntings declined during the period of agricultural recession before the Second World War and subsequently increased during the early recovery of arable farming in the 1950s and '60s (Donald, 1997), but have declined very rapidly since the mid-1970s.

Migratory passerines wintering in West Africa have also experienced population declines (Marchant, 1992). Whitethroats showed a 77% decline in a single year (1969), following drought in the wintering grounds (Winstanley *et al.*, 1974), but have since shown a gradual recovery in numbers, especially in riparian habitats (Crick *et al.*, 1997). The recovery has been slower on farmland, and in other European countries whitethroat numbers continued to decline through the 1980s (Busse *et al.*, 1995). Other species such as song thrush (*Turdus philomelos*), skylark (*Alauda arvensis*) and linnet have declined less precipitously, experiencing sustained long-term declines in numbers (Marchant *et al.*, 1990; Siriwardena *et al.*, 1998).

Summaries of these trends have been prepared for the DETR White Paper "A Better Quality of Life" which uses bird numbers as one of 14 headline indicators of the sustainability of lifestyles in the UK (Anon, 1999). These trends clearly show considerably greater declines in numbers of birds associated with farmland habitats than with any other habitat (Fuller *et al.*, 1995; Gregory *et al.*, 2000). Whereas woodland birds declined by 20% between 1970 and 1998, farmland birds did so by 40%.

Population trends between 1970 and 1998 for widespread and common British species are presented in table 3.1. From 1962 to 1970 many species were recovering from the severe winter of 1962/3 and many CBC sites were being established at this time. Otherwise the period selected is an arbitrary one, chosen because the data are available. For some species (e.g. tree sparrow) there could have been substantial increases in numbers from a relatively low level prior to the recorded declines. However, the fact that declines for species associated with farmland are consistent suggests that this habitat has undergone a change that could have considerable negative consequences for birds in the long term (Fuller *et al.*, 1995).

This was supported by Siriwardena *et al.* (1998) who found that species specialising in farmland habitats had declined more than more generalist species, using farmland as one of many habitats. Their work identifies the point of initial decline for most species as the mid to late 1970s, but farmland species did not comprise a discrete group with similar timing or pattern of changes in population trends. For example, while some seed-eaters declined from the mid 1970s, yellowhammers (*Emberiza citrinella*) did not start to decline until a decade later, and chaffinch (*Fringilla coelebs*) and greenfinch (*Carduelis chloris*) did not decline at all

Gibbons *et al.* (1993) and Fuller *et al.* (1995) have shown that many of the farmland species which have declined in numbers have also experienced British range contractions during the 1970 to 1990 period. For example, corn bunting range contracted by 32%, tree sparrow by 20%, reed bunting by 12% and yellowhammer by 9%. However, not all declining species also showed substantial range changes. Linnet and skylark ranges contracted only by 4.6% and 1.6% respectively, despite declines in numbers by 56% and 54% over the same period.

Table 3.1. Population trends of widespread and common birds in Britain.

Species	1970-1998 trend	Species	1970-1998 trend
Redpoll	-92	Dipper	-6
Tree sparrow[BAP]	-87	Jay	-4
Corn bunting[BAP]	-85	Treecreeper	-2
Grey partridge[BAP]	-82	Greenfinch	-2
Turtle dove[BAP]	-77	House martin	-1
Snipe	-74	Goldcrest	0
Grasshopper warbler	-73	Goldfinch	10
Woodcock	-70	Coot	17
Marsh tit	-69	Little owl	17
Spotted flycatcher[BAP]	-68	Lesser whitethroat	17
Willow tit	-63	Kingfisher	20
Tree pipit	-62	Chiffchaff	26
Redshank	-60	Redstart	30
Starling	-58	Chaffinch	30
House sparrow	-58	Whitethroat	34
Song thrush[BAP]	-55	Garden warbler	35
Lapwing	-52	Blue tit	35
Skylark[BAP]	-52	Pied wagtail	39
Reed bunting[BAP]	-52	Robin	42
Sedge warbler	-45	Coal tit	55
Yellowhammer	-43	Great tit	57
Lesser spotted woodpecker	-42	Long-tailed tit	61
Bullfinch[BAP]	-40	Pheasant	65
Grey wagtail	-39	Wren	69
Linnet[BAP]	-38	Mallard	82
Tawny owl	-30	Green woodpecker	92
Blackbird	-29	Magpie	113
Curlew	-28	Nuthatch	118
Moorhen	-26	Carrion crow	120
Willow warbler	-23	Stock dove	140
Dunnock	-21	Jackdaw	148
Mistle thrush	-21	Blackcap	155
Meadow pipit	-20	Great spotted woodpecker	161
Kestrel	-17	Sparrowhawk	162
Swallow	-16	Reed warbler	194
Common sandpiper	-14	Woodpigeon	201
Yellow wagtail	-13	Buzzard	224
Cuckoo	-12	Collared dove	782
Red-legged partridge	-6		

Source: Gregory *et al.* (2000)

[BAP]: "Red-listed" species which have undergone >50% decline in breeding population or range over the previous 25 years and which are listed as Biodiversity Action Plan species.

Farmland birds have shown similar declines in number and range in other western European countries (Schifferli, 2000). For example, skylark has declined across north-west Europe during the 1970 to 1990 period, and red-backed shrike (*Lanius collurio*), which is no longer a breeding species in Britain, is also declining across most of its European range (Tucker & Heath, 1994). Farmland species that do not occur in Britain and which have declined in other parts of Europe, include Dupont's lark (*Chersophilus duponti*), short-toed lark (*Calandrella brachydactyla*), lesser short-toed lark (*C. rufescens*), thekla lark (*Melanocorypha calandra*), woodlark (*Lullula arborea*) and Ortolan bunting (*Emberiza hortulana*) (Tucker & Heath, 1994). Non-passerines which have declined on European farmland include such species as Montagu's harrier (*Circus pygargus*), lesser kestrel (*Falco naumanni*), little bustard (*Tetrax tetrax*), great bustard (*Otis tarda*), black-bellied sandgrouse (*Pterocles orientalis*), pin-tailed sandgrouse (*P. alchata*) and roller (*Coracias garrulus*). Of the non-passerine species to be declining in both Britain and other European countries, corncrake (*Crex crex*), turtle dove, barn owl and grey partridge are amongst the most severely affected.

Ortolan bunting has declined in Sweden and other European countries since the 1950s (Stolt, 1994). A wider survey of Sweden's birds revealed that, as in Britain, specialist farmland birds had declined more than generalist species (Robertson & Berg, 1992). There is therefore a strong implication across northwest Europe that changes in farming methods may be responsible for declines in numbers of farmland birds. As described in chapter 2, there has been an intensification and simplification of farming practices since the 1970s. These changes could influence breeding numbers of farmland birds through the operation of a wide range of demographic processes.

Demographic causes of population changes are in turn caused by environmental changes, any of which may be influenced by agricultural practices or by other human activities associated with the farmland environment. These environmental factors include the quantity and quality of breeding habitat, the abundance and availability of food in the breeding season, on migration and in winter, and the incidence of predation of adults and nests. Each of these is considered below.

3.2 Breeding habitat

Evidence for habitat availability as a factor limiting breeding abundance comes from removal experiments in which territory holders have been removed and have rapidly been replaced by other, normally younger birds (reviewed in Newton, 1998). This suggests the presence of a floating population of birds that are capable of breeding but fail to do so because of a lack of vacant breeding habitat. However, territories vacated during removal experiments have also been subsequently occupied by pairs from adjacent territories with inferior habitat (Krebs, 1971). No such experiments have been conducted on farmland species, but it is likely that similar principles apply.

Very few of the passerine species regarded as "farmland birds" are associated primarily with cropped land, and most base their breeding territories on hedges and the other non-crop features that form the matrix of the agricultural landscape. Many of the species occurring on farmland are primarily woodland edge species such as blackbird, song thrush, dunnock and robin. Abundance of breeding birds is therefore often correlated with hedgerow length (Lack, 1987 & 1992) and the number of hedgerow intersections (Lack, 1988).

Hedgerow length has declined considerably during the period of passerine declines in Britain, including a 22% decline between 1947 and 1985 (Holloway, 1996). However, the structure of hedges and associated vegetation has also changed over the same period and these are known to affect bird communities in field boundaries. Arnold (1983) found that, in both summer and winter, the number of bird species present in field boundaries increased with the structural complexity of hedges and associated features. Blackbirds, tits, and dunnocks (*Prunella vulgaris*) were associated with relatively tall hedges, while ditch depth increased numbers of song thrush, blackbird, wren (*Troglodytes troglodytes*), robin and yellowhammer.

Parish *et al.* (1994 & 1995) also found a positive correlation between hedge height and bird abundance and diversity in field boundaries. Their study also revealed a relationship between ditch volume and the abundance of blackbird, song thrush, wren and great tit, as well as linnet, reed bunting, goldfinch and skylark. Green *et al.* (1994) found that, while tall hedges were associated with higher numbers of birds, whitethroat, yellowhammer and linnet numbers were negatively related to hedge height, and some of the species associated with tall hedges (dunnock, willow warbler and lesser whitethroat) preferred hedges without trees. Botanical composition of the hedge affected some species, a feature also reported for wrens by O'Connor (1981). However, for this species, hedges represent sub-optimal habitat. Following the cold winter of 1962/3 when many wrens died, woodland was the habitat occupied by remaining birds, with stream sides and hedges being occupied by breeding birds in subsequent years as the population recovered. Breeding densities therefore remain relatively constant in the preferred habitat, with numbers fluctuating more in sub-optimal habitats. For farmland birds, a similar situation is demonstrated for yellowhammer by O'Connor (1981), but with woodland the sub-optimal habitat.

The structure, as well as the length of hedges, therefore has a direct effect on the abundance of many species on farmland. However, the above studies also identified effects of adjacent land use on the abundance of birds in field boundaries. For example, Green *et al.* (1994) found that willow warbler, blue tit and goldfinch showed a preference for hedges associated with grassland over arable, while this was reversed for greenfinch and yellowhammer. Parish *et al.* (1994) found more bird species in grassland field margins than arable, and Arnold (1983) reported an influence of nearby gardens. Gillings & Fuller (1998), studying long-term data from selected CBC sites, found no clear relationship between declines in farmland birds and the loss of non-crop habitats such as hedges. This suggests that either a decline in the *quality* (e.g. structure or botanical composition) of such non-crop habitats, or changes in the nature of cropped habitats, have influenced abundance of breeding birds on farmland.

Rands (1987) found that, as well as hedge length, the amount of grassy vegetation in field boundaries influenced breeding densities of grey partridge, an association also found for yellowhammer (Bradbury & Stoate, 2000) and investigated for whitethroat in this thesis. Herbaceous vegetation in field boundaries is also used by other bird species such as cirl bunting (*Emberiza cirlus*) (Evans *et al.*, 1997) and corn bunting (Brickle, 1998). This habitat has been lost on most farms owing to the misplacement of herbicides and fertiliser from adjacent crops and subsequent spraying or ploughing into the hedge base (Boatman, 1989). Crop management has had a more direct effect on those species associated with crops, rather than non-crop habitats. Of these species, skylark is the one most strongly associated with arable land and has been the subject of considerable research through the 1990s.

Skylark breeding density on arable land is higher in spring cereal and legume crops than other crops such as oilseed rape and winter cereals (Browne *et al.*, 2000). Wilson *et al.* (1997) have shown how high crop diversity, including the use of spring-sown crops, can increase the availability of suitable nesting and foraging habitat through the breeding season, increasing the number of breeding attempts that can be made. This is because different crops attain an optimum structure for nesting and foraging skylarks at different times in the breeding season. However, since 1992, the introduction of set-aside into the arable landscape has provided an additional habitat that supports high densities of breeding skylarks and can be used as a breeding habitat for a longer period of time than autumn-sown crops (Wilson *et al.*, 1997; Poulsen *et al.*, 1998; Browne *et al.*, 2000). Structural diversity within this habitat provides nesting and foraging habitat throughout the summer. Skylark densities are higher on rotational (i.e. first year) set-aside than older, non-rotational set-aside (Henderson *et al.*, 2000), with set-aside becoming increasingly important, relative to winter cereals, as each season progresses (Chaney *et al.*, 1997; Buckingham *et al.*, 2000). This is therefore one species to benefit directly from high structural diversity of crop cover, through extension of the breeding season.

Skylark breeding density was higher on organic farms than conventionally managed farms in one of three years in a study by Wilson *et al.* (1997) and Chamberlain *et al.* (1999). Their work showed that, over all bird species, breeding bird abundance was higher on organic than conventional farms, and that organic farms had smaller fields with higher and wider hedges with more trees than conventional farms. However, these differences in non-crop features are attributable to differences in farmers' attitudes towards them, rather than to the crop management system itself (see chapter 4) (Entec, 1995).

Grassland provides an important breeding habitat for some bird species, including waders such as lapwing, snipe and redshank. Increased intensification of grassland management, including drainage, increased fertiliser application, increased herbicide use, reseeding with modern, productive cultivars and associated increased stocking densities and changes in cutting regimes have been detrimental to breeding birds (Wakeham-Dawson

& Smith, 2000). These species occur at higher densities and have higher breeding success on unimproved grassland, as demonstrated for lapwing by Baines (1988). Interactions with other species also influence the suitability of grassland as a breeding habitat. Stone curlews (*Burhinus oedicnemus*) have a preference for short dry grass, strewn with small stones, and their breeding abundance in Wiltshire has been shown to be positively correlated with the abundance of rabbits which create these conditions (Bealey *et al.*, 1999). Rabbit numbers were also positively correlated with nesting success. In the Calf of Man, numbers of rabbits and sheep were found to be correlated with both abundance and brood size of chough (*Pyrrhocorax pyrrhocorax*), a species which is dependent on short grazed grass as a foraging habitat (McCanch, 2000).

Some habitats occupied preferentially by breeding birds are associated with relatively low breeding productivity because of human actions. For example, skylarks in arable landscapes establish highest territory densities in set-aside, but in the early years of the set-aside scheme, many nests in this habitat were destroyed by poorly timed cutting operations (Poulsen *et al.*, 1998). Oilseed rape is a preferred nesting habitat for farmland reed buntings, but nests are often destroyed by pre-harvest swathing of the crop (Burton *et al.*, 1999). For corncrakes, hay and silage meadows provide suitable nesting habitat early in the breeding season, but nests and young are destroyed when the vegetation is cut in mid-summer and the birds are dependent on other tall vegetation at the start and end of the breeding season (Green, 1996). Lapwings make considerable use of spring-sown cereal crops as a nesting habitat, but nest losses can be very high as these crops are often rolled during the nesting season to retain soil moisture for the crop, with rolling being earlier in autumn- than spring-sown crops (Galbraith, 1988). Destruction of lapwing nests on improved upland grassland can also be high because of high livestock densities (Baines, 1990).

3.3 Food during the breeding season

While summer diet of some farmland passerines (e.g. goldfinch and linnet) comprises mainly weed seeds, most species feeding on seeds during the winter require invertebrate food when feeding nestlings (table 3.2, Wilson *et al.*, 1999). Yellowhammer and corn bunting feed unripe cereal grain to their nestlings, although invertebrates comprise a major part of nestling diet (Wilson *et al.*, 1999). Cardueline finches were formerly dependent on unripe weed seeds for nestling diet, but the introduction of oilseed rape to lowland cropping systems has provided an alternative food source that now forms a major part of nestling diet, as documented by Moorcroft *et al.* (1997). In some species, food abundance is known to influence territory size and breeding density, as demonstrated for dunnock by Davies & Lundberg (1984).

Abundance of both arable invertebrates and the arable weeds on which they depend has declined during the period of increased herbicide and insecticide use, reducing the supply of food for breeding birds (Ewald & Aebischer, 1999; Campbell *et al.*, 1997). Many formerly common and widespread arable weeds are now extremely rare (Wilson, 1990). Herbicide and fertiliser use, timing of cultivation, crop rotation and weed seed dormancy and timing of germination, all interact to contribute to this observed decline in the abundance of many arable weeds (Wilson, 1990).

The decline in grey partridge numbers has been linked to the decline in arable invertebrate abundance (Potts & Aebischer, 1995). In Sussex, partridge density was inversely related to the number of herbicide applications, and positively related to the number of weed taxa (Ewald & Aebischer, 1999). From their analysis of a long-term monitoring project in Sussex (England), Ewald & Aebischer (1999) have shown that the abundance of invertebrate groups that act as food for partridges and buntings is negatively related to insecticide use (and of some to fungicide use). The abundance of host-plants for such invertebrates is negatively related to herbicide use. There was a negative relationship between broad-leaved weed abundance and the use of dicotyledon-specific herbicides, and between grass weeds and broad-spectrum herbicides.

Spring and summer use of herbicides was particularly effective at reducing broad-leaved weed abundance. Of the five invertebrate groups studied, all showed a negative relationship between abundance and the use of insecticides, and declines of four of them were associated with fungicide use. Particularly strong effects were noted for the pyrethroid and organophosphate insecticides, but none of the groups showed a negative relationship with use of the more selective insecticide, pirimicarb, suggesting that broad-spectrum insecticides are most damaging to cereal ecosystems Broad-spectrum insecticides such as dimethoate continue to be the most widely used (Potts, 1997) and can cause substantial damage to populations of beneficial arable invertebrates

Table 3.2. Diet of common farmland passerines.

Bird species	Arthropods	Other invertebrates	Weed seeds	Crop seeds
Skylark	■			
Yellow wagtail	■			
Blackbird		■		
Song thrush		■		
Dunnock	■			
Starling		■		
House sparrow	■			
Tree sparrow	■			
Chaffinch	■			
Linnet			■	■
Greenfinch			■	■
Goldfinch			■	■
Yellowhammer	■			■
Reed bunting	■			
Corn bunting	■			■

Source: Wilson *et al.*, 1999

Spring-sown cereals are historically associated with undersowing of grass leys, a management practice that encourages sawflies (Symphyta) which over-winter as pupae in the undisturbed soil and whose larvae provide an important food sources for breeding birds such as grey partridge, skylark and corn bunting (Ewald & Aebischer, 1999). In Sussex the distribution of breeding partridges and corn buntings is closely related to that of undersown arable leys (Potts, 1997; Aebischer & Ward, 1997) and availability of invertebrates such as sawflies is related to productivity of these species (Potts,1997; Brickle & Harper, 2000). Nestling survival of corn buntings has also been shown to be related to invertebrate abundance (Brickle & Harper, 2000), and this species is strongly associated with low input arable systems with high invertebrate densities in Portugal (Stoate *et al*, 2000).

A long-term national survey of moths, conducted by Rothamsted Experimental Station, reveals that moth species diversity and abundance have declined on farmland since the 1960s, with no such changes being recorded in woodland (Woiwood & Thomas, 1993). More intensive study at Rothamsted has revealed that arable and grassland areas have become poor habitats for moths and numbers and diversity of moths on farmland are sustained only by adjacent non-crop habitats such as woodland and hedges (Woiwood & Thomas, 1993). This is likely to be because of the simplification of botanical communities in these habitats, following increased application of herbicides, and increased use of insecticides during this period. Both adults, and to a greater extent, the larvae of these moths form an important component of the nestling diet of some farmland birds (Wilson *et al.*, 1999; Moreby & Stoate, 2000).

Spray drift into field boundaries where most passerines nest can reduce invertebrate abundance through direct toxicity of the compounds used (Longley *et al.*, 1997) or by reduction or changes in the structure of field boundary vegetation (Haughton *et al.*, 1999). Odderskær and Sell (1993) showed experimentally that reduced invertebrate abundance in field boundaries reduced fledging weights of great tits.

Moreby (1997) showed that herbicide use in cereal crops can suppress abundance of both invertebrates and arable weeds such as chickweed (*Stellaria media*), knotgrass (*Polygonum aviculare*) and fathen (*Chenopdium alba*), the seeds of which provide food for farmland passerines. Moreby *et al.* (1994) found higher weed cover and higher numbers of weed species in organic fields than conventionally managed ones, but differences in invertebrates were inconsistent. Brooks *et al.* (1995) also found similar differences in weed cover and species abundance, and inconsistent differences for invertebrates. In their study, earthworms were more abundant in organic fields that on conventionally managed fields. This is likely to be due to the presence of longer grass ley periods in organic systems, as suggested by Higginbotham *et al.* (2000) who found similar differences in worm abundance between the two systems.

In a study of skylarks, Poulsen *et al.* (1998) found higher numbers of Lepidoptera and Symphyta larvae, Hemiptera and spiders (all known skylark nestling food) in set-aside than in other arable fields. Symphyta larvae are also known to occur at higher densities in undersown grass leys and the loss of these from arable rotations is likely to have reduced the invertebrate food available to breeding birds (Potts, 1997). Poulsen *et al.* (1998) found that skylark clutch size was higher in first-year grass set-aside than other arable fields, and for this and other species, relatively high invertebrate abundance might enable adult birds to enter the breeding season in better condition, resulting in earlier nesting or larger clutches. Livestock grazing pasture at low densities can also increase invertebrate abundance (e.g Elligsen *et al.*, 1997) and dispersal (Warkus *et al.*, 1997), but high livestock densities associated with intensive management of grassland can reduce invertebrate numbers (van Wingerden *et al.*, 1991).

Simplified arable systems with high external inputs have therefore resulted in reduced abundance of invertebrate food for breeding farmland passerines whose fledging success or number of breeding attempts or post fledging survival may be reduced as a result.

This could influence breeding abundance in subsequent years. Breeding densities of some North American warblers are known to be related to the abundance of caterpillars in previous summers (Newton, 1998). However, while for some European farmland birds (e.g. corn bunting, lesser kestrel) fledging success or breeding density have been shown to reflect invertebrate abundance, only for grey partridge has invertebrate abundance been shown to limit breeding populations (Potts, 1986).

3.4 Predation

Nest predation is the largest single cause of nest failure for most species (Groom 1993; Crick *et al.*, 1994) and predation rates are determined by a range of factors whose importance varies between species. Tuomenpuro (1991) found that nest concealment influenced predation rates of dunnock nests. Howlett & Stutchbury (1996) found that nest concealment was not an important influence on predation of the nests of hooded warbler (*Wilsonia citrina*), while Cresswell (1997) found that blackbird nest concealment influenced predation rates of artificial nests, but not of natural ones, and attributed the higher survival of the latter to adults' defensive behaviour. There is some evidence to suggest that adult body condition, influenced by food availability, affects the efficacy of nest defence by fieldfares (*Turdus pilaris*) (Hogstad 1993), and similar environmental influences could operate for other thrush species. Götmark *et al.* (1995) working on song thrushes reported a trade-off in the selection of nest sites between the need for concealment and the need for observation of predators. Working in America, Martin

(1988) found that successful hermit thrush nests were in sites surrounded by more alternative nest sites than unsuccessful nests, and that these sites with abundant nesting habitat are the preferred breeding habitat.

Artificial nest experiments have suggested density dependent effects of predation. In Britain, this was the case for artificial blackbird nests monitored by Chamberlain *et al.* (1995) on farmland and woodland edge, with highest nest predation occurring in areas of highest nest density. In most circumstances, such dependence is likely to be determined by density of all species with similar nest characteristics in any one area, rather than on the density of any single species. In America, Martin (1993) suggests that partitioning of nest sites by different species between different habitats and vegetation layers is driven by the probability of predation in each habitat. American workers have also suggested an influence on nest predation rates of habitat fragmentation as woodland has been cleared for farmland, with a wider range of predators occupying these landscapes (Yahner *et al.*, 1989). There are similar influences in Europe, with generalist predators such as corvids benefiting from the combination of woodland, hedges and open farmland (Andrén, 1992). In their analysis of a national dataset, Paradis *et al.* (2000) found a negative relationship between corvid abundance and nest survival of blackbirds and song thrushes in Britain, although in their study, corvid abundance was correlated with latitude and associated factors.

Predation rates are also influenced by the abundance of alternative food for predators. For example, abundance of weasels (*Mustela nivalis*) (Tapper, 1979) and their predation of nesting tits (Dunn, 1977) have been shown to be directly related to the cyclical abundance of the weasel's main prey species, field vole (*Microtus agrestis*). Such interactions are common. Wet weather increases the abundance of earthworms available to corvids foraging on pasture (Edwards & Lofty, 1977), and may divert predation pressure from thrush nests. Such increased availability of earthworms may also be exploited by thrushes, reducing their foraging time and increasing vigilance against nest predators. Availability of invertebrate food for cirl bunting nestlings is likely to limit nestling survival, but mortality may also occur through increased predation because the calling of unfed nestlings attracts the attention of predators (Evans *et al.*, 1997).

Martin (1995) demonstrated that annual productivity of American passerines was inversely related to adult survival and the same principle may apply within species so that increased adult mortality compensates for increased productivity. This was the case for the great tits studied by McCleery *et al.* (1996). In their study, female survival was negatively related to the number of successful nesting attempts. Such extra mortality could result from the increased reproductive costs and increased competition between adults at high density.

Predation of adult birds is most likely to impact on breeding populations when it occurs during or immediately prior to the breeding season. Sparrowhawks (*Accipiter nisus*) are a major predator of woodland and farmland birds in Britain and studies of their impact on passerine communities have been documented. Newton & Perrins (1997) monitored changes in passerine numbers during a period in which sparrowhawks were present in their study area, a period in which they were absent as a result of organochlorine use in agriculture, and a subsequent period in which hawk numbers recovered. No passerine species increased during the period of sparrowhawk absence, or declined on its return, a finding corroborated by a wider survey by Thomson *et al.* (1998). An intensive study of great tits and blue tits by Perrins & Geer (1980) produced similar findings, despite high levels of predation of tits by sparrowhawks. Dhondt *et al.* (1998) reported a decline in adult blue tit survival rate (relative to neighbouring areas) when sparrowhawks started breeding in their study area, but blue tit breeding density did not change, even though most predation occurred early in the breeding season. They attribute this to the presence of a non-breeding population which did decline.

On migration, as well as mortality resulting from adverse winds or other weather conditions, many birds are killed by hunters and other predators in the Mediterranean. In the European Mediterranean, most hunting occurs in the autumn, while in the African Mediterranean countries more hunting takes place during the spring migration when the impact on breeding populations is likely to be greater (McCulloch *et al.*, 1992). Many birds are taken as prey by raptors. Of these Eleonora's falcon (*Falco eleonorae*) specialises in hunting migrants and times its breeding to coincide with the appearance of migrating warblers on the Mediterranean coast in autumn (Alerstam, 1990). Predation by raptors is also a factor limiting pre-migratory fattening as heavy fat loads reduce manoeuvrability for predator avoidance (Houston & McNamara, 1993).

In breeding areas, control of predators, as part of wild gamebird management, results in increased nesting success and breeding densities of grey partridge (Tapper *et al.* 1996). Aebischer (1991) describes an interaction between the effects of herbicide use and predator control on the breeding abundance of grey partridges, in which numbers increase only when herbicide use on crops is restricted *and* predators are controlled during nesting. Implementation of one or other of these factors alone results in little change in partridge numbers. However, for farmland passerines, there is little evidence that nest predation limits breeding populations. Nationally, nesting success has increased over the period of population decline for species such as song thrush and dunnock (Crick *et al.* 1997), and such declines are therefore unlikely to be due to simultaneous increases in corvid numbers.

Increased levels of nest predation have been implicated in parallel declines in numbers of passerines in North America (Wilcove 1985; Böhning-Gaese *et al.* 1993; Sherry & Holmes 1992; Terborgh 1992), while removal of non-indigenous nest predators of some endangered bird species in New Zealand has resulted in improved nesting success and recovery of breeding numbers (O'Donnell 1996). No studies of effects of experimental predator removal on passerine nesting success or breeding abundance have been conducted in Europe (Côté & Sutherland, 1996). However, Gooch *et al.* (1991), Thomson *et al.* (1997) and Thomson *et al.* (1998) present correlative evidence that suggests no relationship between breeding abundance of corvids and their prey.

3.5 Food during migration and in winter

Migrating passerines accumulate fat amounting to 30-40% of their fat-free body weight prior to autumn and spring migrations. This is achieved by active feeding and in the case of insectivores, a change in diet from invertebrates to fruit, and a corresponding change in gut structure to accommodate this (Barlein & Simons, 1995). The timing of pre-migratory fattening is adjusted to accommodate the needs for pre-migratory moult (Lindström *et al.*, 1994) and is also associated with development of flight muscles (Piersma, 1990). Insufficient fat deposits require migrants to stop during the migration at sites where the supply of food is uncertain and competition may be high (Moore & Yong, 1991). Perhaps for this reason, some species depending on scarce patchily distributed feeding habitats show some degree of site fidelity during migration (Cantos & Telleria, 1994, Stoate, 1998).

On autumn migration most British-breeding species travel south through France to Spain and Portugal where they accumulate enough fat to fuel the remaining journey across the Sahara. Efficient use of fat is enhanced by northerly tail winds and migrants therefore time their departure from Europe to coincide with these. On the spring migration, northerly winds across the Sahara predominate and can be stronger than in the spring. The northward migration is therefore more hazardous, although it is also shorter as birds can stop in the southern Mediterranean countries where vegetation is growing following winter rains and food is therefore relatively abundant. Southerly winds are more frequent in the eastern Mediterranean and many migrants therefore make the spring migration to the east of their autumn routes (Alerstam, 1990).

In sub-Saharan wintering areas migrants occur mainly in seasonal savannas and open woodland, mostly using temporarily and locally abundant food sources that are generally under used by resident species (Leisler, 1992). Many species therefore occupy the Sahel and Sudan zones where pastoral and subsistence arable cultivation are the main landuses. Most of these migrant species are insectivores and arrive at the end of the rainy season when arthropods numbers are high, but subsequently decline. Migrants are able to exploit an abundance of relatively small prey items as they have consistently higher foraging rates than resident tropical birds which exploit the abundance of larger arthropods present during the rains (Thiollay, 1988; Greenberg, 1995). Migrants are also able to exploit a wider range of habitats than residents and are more often associated with habitat disturbance, normally caused by humans (Leisler, 1992). In some species, such as great reed warbler (*Acrocephalus arundinaceus*) males and females occupy different habitats, increasing the range of habitats and food exploited (Nisbet & Medway, 1972). Opportunistic exploitation of habitats and food sources as they become available is a characteristic survival strategy for migratory passerines in winter.

Because of their association with anthropogenic habitats, survival of migratory passerines is likely to be strongly influenced by agricultural activity, including the management of woody vegetation on farmland (Stoate, 1997 & 1998). Clearance of dense forest for agriculture is likely to have benefited migratory passerines at the expense of African residents, but subsequent further loss of trees and shrubs from farmland is detrimental to both groups.

Pesticide use in Africa is less widespread than in Europe where it is known to reduce availability of invertebrate food. However, the continued use of organochlorine insecticides in Africa, following their ban in Europe, was associated with the continued presence of DDT and lindane in the muscle tissue of whitethroats returning to their breeding sites (Persson, 1972). Parallel results have been obtained more recently for a range of Neotropical migrants (Kannan, 1991), although the sub-lethal effects of these compounds are poorly understood.

Physiological and behavioural changes associated with migration, as well as the direction of that migration, are genetically determined, with some individuals showing aberrant (mutant) directional movements which may be favoured by natural selection as and when environmental conditions change (Berthold & Helbig, 1992). For example, blackcaps (*Sylvia atricapilla*) from northern Europe migrate to southern Europe where individuals show some site fidelity between years (Cuadrado *et al.*, 1995). However, increasing numbers of individuals are now wintering in northern Europe, with German blackcaps taking a west-north west route to southern Britain (Busse, 1992). The increased suitability of Britain as a wintering area is likely to be due to the increasing provision of food through the winter at garden bird tables, and perhaps to reduced frequency of severe winter weather.

Seed-eating species that do not migrate, or make only cold weather movements, also accumulate fat in the autumn, but continue to do so through the winter as energy reserves against uncertain food availability associated with food depletion and bad weather. Snow cover is known to have a greater impact than other meteorological variables on breeding densities of both woodland and farmland birds (Greenwood & Baillie, 1991). Evans (1969) found that fat content of the highly sedentary yellowhammer (with a constant food supply) increased from 20% of lean dry weight to 40% between November and January and subsequently declined through to March. Fat content was not correlated with temperature on the sampling day, but was correlated with the long-term average temperature for that day. This same pattern of increase and subsequent decrease in fat content has been reported for other species in temperate regions (Rogers & Rogers, 1990).

Insufficient fat results in insufficient energy to survive the night and foraging for unpredictable food supplies the following morning, and the requirement for fat reserves therefore increases with night length. The observed pattern is for both dawn and dusk weights to increase towards maxima in mid-winter and then decrease (Houston & McNamara, 1993). However, as indicated for pre-migratory fattening, excessive winter fattening can make birds vulnerable to avian predators because they spend more time foraging and are less manoeuvrable (Houston & McNamara, 1993). Birds therefore maintain lower than potential fat levels, even when food is abundant (Bednekoff & Houston, 1994). Gosler *et al.* (1995), examining historical data for great tit at Wytham

Woods, found that fat deposition increased during the 1960s when sparrowhawks were absent, and declined during the 1970s and early 1980s as sparrowhawks recolonised the area. Pilastro *et al.* (1995) have shown that for wrens, large home ranges were positively correlated with body size, and negatively correlated with fat reserves.

However, Grubb and Cimprich (1990) have shown that supplementary feeding can improve the nutritional condition of wintering birds, as measured by feather growth. Descriptive and experimental studies suggest that winter survival of some species, especially of young birds, is related to available food, although such studies do not include farmland birds (Newton, 1998). In part, increased survival in the presence of high food availability, results from increased vigilance associated with shorter foraging times, and therefore reduced predation. The result can be increased spring dispersal, rather than increased breeding densities, although exceptions are known for some woodland species (e.g. great tit, Newton, 1998).

Bimodal foraging with activity concentrated at dawn and dusk, avoids excessive fat accumulation and reduces mass dependent predation (McNamara *et al.*, 1994). Predation risk also influences choice of foraging site in relation to cover which appears to be perceived by birds as both a source of, and protection from predators (Lima *et al.*, 1987). Birds foraged closer to open cover than dense cover. However, foraging behaviour in relation to cover varies with species, as demonstrated experimentally by Lima & Valone (1991). Robinson and Sutherland (1999) found that yellowhammers foraged closer to hedges than did skylarks which moved closer towards hedges as the winter progressed and the abundance of seed food declined. Birds feeding close to cover tend to increase vigilance and reduce feeding rate (Metcalfe, 1984). Flocking enables individuals to reduce vigilance and increase feeding rate, as demonstrated for goldfinches by Glück (1986).

Within agricultural ecosystems, winter food abundance has declined over the past half century as livestock and their winter feed sites have been lost from many farms, increased autumn cultivation has been associated with loss of winter stubbles, and improved herbicides have reduced abundance of seeding weeds in any stubbles remaining. Evans (1997), Wilson *et al.* (1996b), Donald & Evans (1994), Evans & Smith (1994) and others have documented the considerable use of stubbles by seed-eating birds on farmland in winter, relative to other farmland habitats.

Although there is currently limited evidence for a causal link between loss of winter food, reduced winter survival and declines in breeding abundance of farmland birds, the evidence available suggests that this is likely for many passerine species (Siriwardena *et al.*, 1999). Provision of weed-rich cereal stubbles has been a central component of the successful restoration of cirl buntings in Devon, although management practices designed to benefit cirl buntings in the breeding season have also been adopted (Lock, 1999).

3.6 Demographic processes

A change in overall population size will have an ultimate environmental cause (as described above) which is mediated through some proximate demographic change such as reduced survival rate or change in the density dependence of survival. Most studies of causes of farmland bird population change have focused on either correlations between environmental change and population size or on correlations between demographic change and population size. Much or our current knowledge of farmland bird ecology is derived from intensive ecological studies at individual sites. These studies provide the information needed to identify the critical resource requirements for species of conservation interest. The processes involved in the declines of farmland birds have become better understood as a result of modelling studies of demographic responses to environmental factors.

For the U.K., population data are based on Common Birds Census data which date back to the early 1960s and therefore cover the main period of population decline for farmland birds. Historical data are also available for the demographic variables, survival rates, nest success and clutch size, but not for post-fledging survival, or for the number of breeding attempts.

Demographic models identify the influences of individual demographic parameters, but rarely assess the potential influence of environmental factors. Where such analysis has been attempted, it has suggested an influence of adult and first-year survival on population trends of song thrush (Thomson *et al.*, 1997), reed bunting (Peach *et al.*, 1999), pied wagtail (*Motacilla alba*), robin (*Erythacus rubecula*), blackbird (*Turdus* *merula*), mistle thrush (*T. viscivorus*), lesser whitethroat (*Sylvia curruca*), whitethroat, blue tit (*Parus caeruleus*), great tit (*P. major*), chaffinch and redpoll (*Carduelis flammea*) (Siriwardena *et al.*, 1999). Siriwardena *et al.* (2000) have suggested that the same might also apply to yellowhammer. Only for linnet was nesting success suggested as driving changes in the population trend, although for turtle dove and tree sparrow, the population trend can be explained by a combination of adult/first-year survival and the number of fledglings per nesting attempt (Siriwardena *et al.*, 2000). However, as indicated earlier, these analyses of BTO data, collected by volunteers, do not include assessment of post-fledging survival or number of breeding attempts per individual per season. In intensive studies, post-fledging survival has been implicated in the decline of song thrush (Thomson & Cotton, 2000) and number of nesting attempts in that of skylark (Wilson *et al*, 1997), lapwing (Beintema *et al.*, 1997) and corncrake (Green & Williams, 1997). As suggested for great tit, there may be a trade-off between number of nesting attempts and adult post-breeding survival. The implications of this interaction for bird conservation have not been considered.

For linnet, the one passerine species whose population trend, Siriwardena *et al.* (2000) suggest may be driven by reproductive success, pastoral landscapes, crop diversity and fallow area were all associated with higher nesting success, while rape crops were associated with reduced nesting success. However, reduced nest success was only at the egg stage, so here again, the number of nest attempts may be an important influence. Evidence from Moorcroft & Wilson's (2000) intensive studies suggest that rape has replaced weeds as the main source of nestling food. However, the greater diversity of the weed flora in grassland and mixed farming areas may prolong the effective foraging time available to breeding linnets, relative to intensively managed rape and cereal systems. Siriwardena *et al.* (2000) suggest no relationship between cropping and adult survival, the parameter most strongly associated with population declines. However, this may reflect the limitations of such a broad scale approach to agricultural systems.

Breeding numbers of many migrant species are currently declining and Baillie and Peach (1992), using BTO data, demonstrate that winter mortality is sufficient to explain annual changes in breeding numbers of whitethroat and sedge warbler (*Acrocephalus schoenobaenus*), and that these are correlated with rainfall in each species' wintering area. A similar relationship between breeding abundance and African rainfall has been shown for sand martin (*Riparia riparia*) (Szép, 1995). Although the mortality associated with migration is poorly understood, mortality of some migratory passerines on their wintering areas and on migration therefore limits breeding abundance in northern Europe.

3.7 Population distribution

Bird populations are not evenly distributed across a landscape. This non-random distribution within a heterogeneous environment is in line with the ideal-free distribution model described by Fretwell and Lucas (1970), in which territorial birds are distributed unevenly, according to the quality of the habitat. In the case of birds which forage within their defended territories, this tends to result in smaller territories being defended in high quality habitats with the consequence that territories in sub-optimal habitats are larger as well as being present at lower density. Breeding populations in sub-optimal habitats also fluctuate more than those in preferred habitats.

Pulliam (1988) argues that "for many populations, a large fraction of individuals may regularly occur in 'sink' habitats, where within-habitat reproduction is insufficient to balance local mortality; nevertheless, populations may persist in such habitats, being locally maintained by continued immigration from more-productive 'source' areas nearby". Populations with differing demographic processes are therefore in continuous contact with each other with individuals dispersing freely between them. This model is likely to be appropriate for most widely distributed farmland bird species. An alternative (Levin, 1970) proposes that sub-populations are isolated and with equivalent demographic processes, and local extinction or colonisation are determined stochastically. This model is less applicable to most bird populations because of greater dispersion and dispersal than, for example, some sedentary invertebrates.

For the corn bunting, whose numbers in the U.K. declined by 85% between 1970 and 1998 (Gregory *et al.*, 2000), the breeding distribution is continuous over large areas, but reflects the distribution of spring cultivation, with a strong association with arable areas with light soils (Gibbons *et al.*, 1993). Population declines are thought to have been driven by increased winter mortality following loss of stubble foraging habitats, and reduced productivity following reduced invertebrate abundance (Brickle, 1998). Natal dispersal of this species is low, with Shepherd *et al.* (1997) reporting all surviving individuals returning to within 5km of their natal area. Aebischer and Ward (1997) and Brickle (1998) have shown how the corn bunting's decline in Sussex was associated with a contraction to areas which incorporated spring-sown barley and undersown leys in the arable rotation, and where corn bunting density and productivity were generally highest. Winter stubbles in these farming systems provide seed food in winter, so that winter survival may be higher than in areas where they are absent. Productivity would exceed mortality. In this case, these areas of light land and spring cultivation would represent 'source' habitats, and heavy land autumn-cultivated areas which were formerly occupied by corn buntings may represent 'sinks'.

The corn bunting may therefore provide an example of a 'metapopulation', in which a series of sink and source populations is linked through dispersal, but isolated from other 'metapopulations' of the same species (Wilson & Griffiths, 1997). This concept of a metapopulation, incorporating sink and source sub-populations, is important in terms of conservation, as targetting conservation management towards a sink sub-population where the species has declined may be ineffective if source areas with stable populations are not also targetted.

Isolation of metapopulations has implications for the demographic sustainability of populations. In a stable or increasing population, individuals from sink populations disperse to sources (Morris, 1991). When the metapopulation is declining, local populations become increasingly isolated. The probability that sink populations will be sustained is reduced and the viability of source populations is threatened. An extreme example of such contraction of a formerly widespread farmland species is provided by the corncrake, in which the demographic viability of breeding populations has become threatened by their isolation as well as by their small size (Gibbons, *et al*, 1993). This is also the case for the cirl bunting where conservation benefits of habitat management are only realised if they are carried out close to occupied sites (Peach *et al.*, in press). Stone curlews also have a highly restricted distribution, and like corn buntings, occur on geographically restricted light, free-draining soils and have restricted dispersal (Gibbons *et al.*, 1993). Each of these species, with breeding distribution across spatially discrete sites, is therefore the subject of conservation concern and action as the probablity of recolonisation at individual sites depends on the site's size and isolation from potential sources of colonisation.

3.8 Implications for research and conservation

A combination of intensive, normally small-scale ecological studies, and population modelling based on large-scale (normally national) datasets, has provided a considerable amount of information of relevance to the practical management of bird populations. As the previous sections have shown, the range of requirements, even for a single species, can be considerable, and satisfying these requires considerable control over the management of habitats. This is possible on relatively small areas owned by conservation organisations, but is more difficult over the large areas of independently managed farmland which are the habitat for currently declining bird species.

A few conservation projects have applied considerable research and management effort to the conservation of single species within defined areas of farmland to the benefit of corncrake, stone curlew and cirl bunting (Aebischer *et al.*, 2000). Wider conservation actions for farmland birds are being directed through agri-environment schemes, but even these currently cover only 6.7% of agricultural land (Swash *et al.*, 2000). While single species projects can incorporate the motivation of individual farmers into management plans, this is less often the case for schemes with wider objectives (e.g. Wilson, 1997a). However, actions motivated by farmers' game shooting interests can have conservation benefits (MacDonald & Johnson, 2000), and this form of management has potential for the conservation of birds in the wider countryside.

Wild gamebirds, like the species already considered in this chapter, are influenced by a wide range of environmental factors, including the availability of breeding habitat, the abundance and availability of food during the breeding season and in winter, the abundance of cover in winter, and the abundance of nest predators. Farmers with shooting interests adapt the management of their farmland to meet these requirements through the year.

The extent to which game management contributes to conservation of wildlife, including species whose populations have declined coincident with agricultural intensification, has not been demonstrated. The research presented in this thesis investigates the conservation potential of game management using a single farm, Loddington, in

Leicestershire which is managed according the requirements of wild pheasants and partridges identified by long term research into these species (Potts, 1986; Robertson & Hill, 1988). For one common farmland species, the whitethroat, habitat use on farmland in both breeding and wintering areas, is investigated in more detail, and the motivation for the management of these habitats by farmers is explored.

The work described in chapter 5 aims to test the following hypotheses:

- Numbers of breeding passerines increase in response to management of a wild gamebird population
- Control of corvids as part of the management of wild gamebirds contributes to increased passerine nest success

The second hypothesis was tested by manipulating corvid numbers at three sites, but an experimental approach involving switched treatments was not possible because Loddington serves as a demonstration farm as well as being a research centre. Although not experimental, the study incorporates comparative local data to explore the hypothesis that management of wild pheasants for shooting increases breeding abundance of farmland passerines. Potential processes by which this might occur are described in figure 3.1. The extent to which different components of this model (and therefore the management responsible for them) might influence breeding abundance is likely to differ between species. Chapter 6 of this thesis investigates this process for one species, the whitethroat.

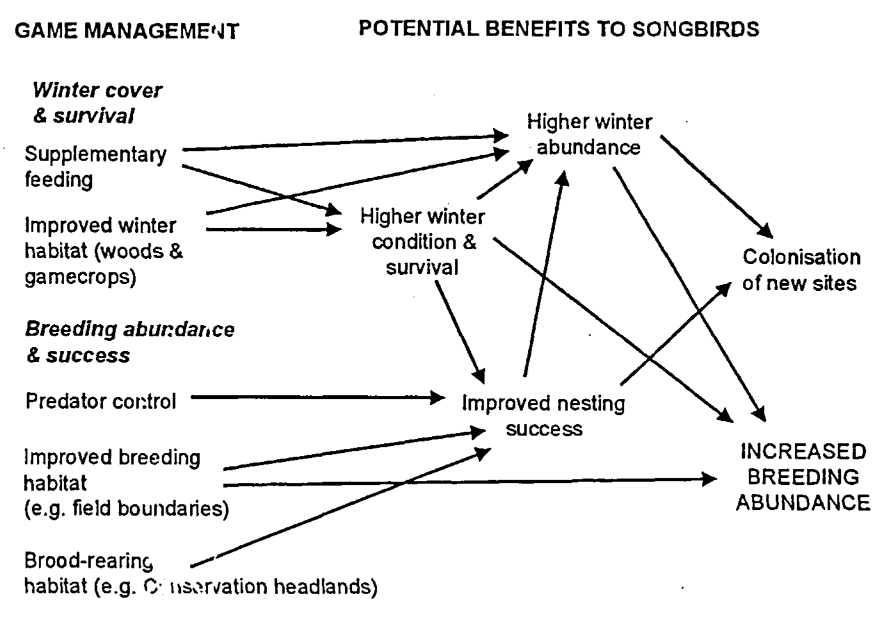

Figure 3.1. Conceptual model of processes by which farmland passerines might benefit from game management practices. Density dependent feedback effects of breeding abundance are not shown.

3.9 Whitethroats as a case study

The whitethroat is a migratory warbler that breeds on farmland in northern Europe, including Britain, and winters on farmland in the western Sudan region of sub-Saharan Africa. Farmer behaviour therefore influences the habitat of this species in both regions. British breeding birds are known to winter mainly in Senegal (Dowsett *et al.*, 1988), and survival in the wintering area is thought to be the key factor limiting breeding abundance

(Baillie & Peach, 1992). Like the grey partridge, its primary nesting habitat on farmland in Britain is herbaceous vegetation in field boundaries, a habitat that is strongly influenced by the management of adjacent crops by farmers (Figure 3.2).

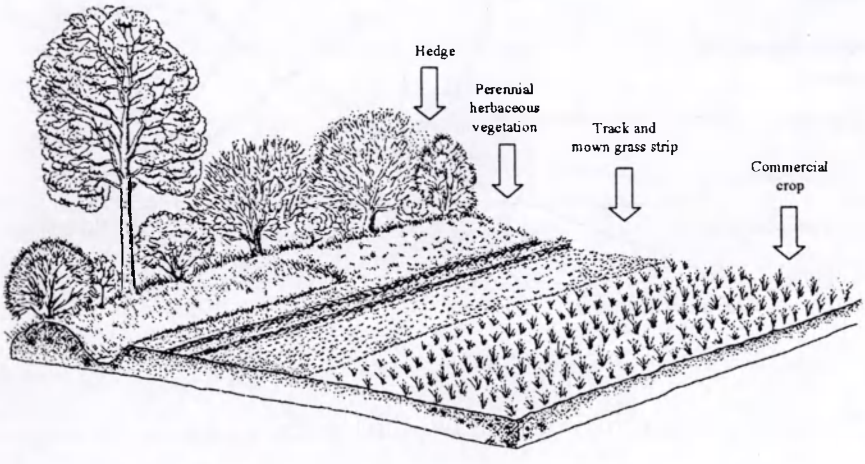

Figure 3.2. Design for structurally diverse field margin habitat, incorporating hedge, tussocky perennial herbaceous vegetation, short grass and commercial crop (source: Sotherton & Page, 1998).

Chapter 6 investigates to what extent management of field boundary habitats might limit local breeding abundance of whitethroats. This work tests the hypothesis that whitethroats exhibit a non-random use of field boundaries when establishing breeding territories on farmland, and that this use is influenced by type and structure of field boundary vegetation. Chapter 7 then investigates farmers' motivation for conservation management. Chapter 8 explores the parallel relationship between habitat use by whitethroats and its management by farmers at a site in the whitethroat's wintering area on the northern Gambia/Senegal border.

In combination, the research into the response of a bird community to the implementation of game management, and the more specific work on whitethroats, aim to improve our understanding of how farmers' management behaviour can influence breeding abundance in an area used by farmland birds. The results have practical implications for the conservation of these species.

3.10. Synthesis

This chapter has described the very wide range of factors influencing the demographic processes that affect bird abundance, many of which occur on farmland in Britain, on wintering areas in West Africa, or on migration.

The environmental influences driving demographic processes have been affected by intensification of farming during the second half of the twentieth century. The evidence available suggests that this essentially economically driven process has reduced nesting success and winter survival, and caused direct reduction of breeding abundance through loss of suitable habitat. In addition to economics, the cultural values of farmers have played a part but have received little attention in the past. In Britain, management of wild gamebirds for shooting aims to meet the ecological requirements of game species throughout the year. Many of the management practices intended to benefit gamebirds may also result in increased nesting success and winter survival of farmland passerines. Their breeding abundance may therefore be increased indirectly, through these processes, or directly through provision of suitable habitat.

In West African wintering areas, management of farmland may also be modified to meet the economic and cultural objectives of farmers, while at the same time, improving habitat for migratory birds. The interaction between cultural and agricultural influences on the management of whitethroat habitat on farmland is explored in chapters 7 and 8. Chapter 4 reviews the role of cultural and socio-economic influences on farmland management.

Chapter 4

Cultural and socio-economic influences on farmers' management strategies

Throughout the geographical range occupied in summer and winter by British-breeding farmland birds, management decisions made by farmers influence the habitats available to these birds. Such decisions are in turn influenced by a wide range of factors associated with the farmland environment, the market for agricultural products, and the interests of the farmer. Environmental factors include climate, topography and soil type.

Within the sub-Saharan region occupied by many migratory birds in the northern winter, similar environmental constraints apply. Here, the north is a pastoral, livestock rearing area and the wetter southern belt is more wooded with a different range of arable crops from the central belt which is the main arable region.

Economic opportunities and constraints are a major influence in both northern Europe and sub-Saharan wintering areas, but differ considerably in nature between the two areas. The Common Agricultural Policy (CAP) of the European Union provides support for both arable and livestock production and helps to maintain stable prices for European farmers. Economic support for environmental management on farmland is also available to farmers through agri-environment schemes. The lack of similar economic support for sub-Saharan farmers means that the market for crops in Africa is subject to both local fluctuations in market prices, and to marketing of the same or alternative crops in the north. The vagaries of the climate in sub-Saharan Africa, coupled with low yields, add to the economic uncertainties of farming in this region.

Farmers in most of the sub-Saharan winter range of migrant birds are therefore considerably more economically constrained than those in the north and many manage their farms at, or little above, subsistence levels. Disease incidence is also a greater influence on farming activities in southern countries, especially during the rainy season when labour demands for weeding are high (Weisner, 1980; Desowitz, 1980). However, in both northern and southern regions, cultural factors play an important role in influencing farmers' management decisions and practices, with substantial consequences for birds on farmland. Such decisions are driven by the development of aesthetic, moral, recreational and dietary preferences, often associated with social activities within the dominant culture.

Douglas (1996) defines culture as "the publicly shared collection of principles and values used at any one time to justify behaviour" and "the individual's sense of social environment". Young *et al.* (1995) extend this to the physical environment by arguing that "farming culture exists within individual farmers' minds as a set of values or attitudes that they use to make sense of their relationship with the environment". Farming culture is "socially constructed to justify actions and mediate (environmental) problems in production [and] does not have a separate 'existence' but is brought into being (made real) as people refer to it to justify their actions" (Young *et al.* (1995). Culture "is not what people are doing ... it is the way that people make sense of what they have done" (Mitchell, 1995).

4.1 Cultural ecology and farmer behaviour

Orions and Heerwagen (1992) argue that, across a range of cultural groups, people have an aesthetic preference for savanna type landscapes comprising trees and open spaces. As with many features of human behaviour, this preference is thought to be a genetically determined aspect of human psychology. Such cultural evolution would have occurred during the Pleistocene over millennia of human evolution as hunter-gatherers in savanna environments. This habitat selection would be necessary several times during the lifetime of any individual, and would be a strong influence on survival and reproductive success, and therefore a powerful selection factor.

This aesthetic preference for savanna type environments is stronger in children than in adults whose judgements have been influenced by environmental and social experience (Orions & Heerwagen, 1992). Genetically determined cultural values therefore can be modified according to environmental influences arising from lifetime experience of individuals. However, universal evolved psychological mechanisms provide the framework for such modification. This is illustrated most convincingly for language in which it is proposed that "children must be equipped with specialised mechanisms ('mental organs') that are functionally organised to exploit certain grammatical universals of human language" (Tooby & Cosmides, 1992). The language each child adopts is culturally determined according to his or her social environment.

Most cultural changes occur very much faster (within single generations) than evolutionary history. Although not genetically determined, such changes are currently thought to follow broad Darwinian principles of natural selection (Dawkins, 1976; Tooby & Cosmides, 1992, Sperber, 1996). In this case, transmission of culture between individuals is determined by combined environmental and social influences. It is contagious and analogous to an epidemiology of culture – a "psychological susceptibility to culture" (Sperber, 1996). Sperber distinguishes between traditions which are slowly transmitted over generations (endemic), and fashions which are rapidly transmitted and short lived (epidemic). In both cases, transmission can be by communication or by imitation of observed behaviour.

The individual becomes "one of many loci among which is distributed the pool of cultural representations inhabiting the population" (Sperber, 1996). Competition between cultural behaviours leads to changes in their relative influence and adoption within a population, according to environmental and wider social factors (e.g. tradition). Cultural values are therefore fluid, and socially contested through such processes as prestige, stigma and group allegiance.

This is illustrated by food taboos and their consequent impact on agricultural activity. The keeping of pigs and eating of pork have long had strong cultural associations. Diener and Robkin (1978) and Eder (1996) argue that pigs were prohibited within Islam for reasons of collective identity, to establish cultural boundaries between this religion and others, including Christianity. As well as removing pigs from the Muslim farming system, the absence of lard as a cooking fat encouraged establishment of olive groves for oil production within agricultural landscapes (Diener & Robkin, 1978). It is perhaps because of this role in cultural identity that the olive tree continues to occupy an important place in Muslim *Sunna* (Izzi Dien, 2000). Olives are an important food source for some British-breeding migratory birds in the Mediterraean.

Within countries, taste is also culturally determined, and differences in diet and eating times and places reflect social status and cultural identity (Wood, 1995; Eder, 1996; Douglas, 1996, Warde, 1997). In his account of the sociology of food, Warde (1997) describes the conficting influences of novelty and tradition (and even the 'invention of tradition') in the late 20th century British diet. This parallels Sperber's (1996) account of the role of tradition and fashion in cultural evolution and is likely to be reflected in behaviour other than diet. Farmers' behaviour accommodates both activities perceived as traditional, such as hunting and shooting, and those perceived as progressive, such as field enlargement and adoption of the latest equipment.

Non-food items are used as expressions of identity through competitive consumption within farming communities. Thomas (1996) describes prestige exchanges seven thousand years ago between the LBK (*Linearbandkeramik*) people of central Europe and the communities immediately to the north in Denmark and Sweden. Of the latter, Ertebølle people are recorded as adopting LBK "point-butted" pottery and other exotic artefacts, enhancing the social position of individuals within these foraging bands. Signs of domesticated plants and animals appeared amongst Ertebølle communities at the same time. It is likely that such food items were also prestige items before they became the staple diet and the focus for agricultural activity in northern Europe (Thomas, 1996). Rausing (1998) provides a modern example of the adoption of western (Swedish) culture in an Estonian farming community being articulated in terms of the appropriation of western objects, ranging from farm equipment and clothing to empty shampoo bottles decorating bathroom shelves. Cultural influences are therefore reflected in both agricultural and domestic behaviour within agricultural communities, with a consequent impact on both agricultural and domestic environments. These cultural influences combine with socio-economic, demographic and technological influences to determine the nature of the modern farmland environment (van Mansvelt, 1997; Giampietro, 1997).

Modern communication enables adoption of novel cultural objects and behaviour to operate on a global scale and at a faster rate than in the past. In many developing non wheat growing countries, wheat bread is increasingly adopted, first as a prestigious food, and then as a common staple, in preference to indigenous equivalents such as millet (*Pennisetum typhoides*) (Schudson, 1994). Homogenisation of farmland landscapes also results from the global adoption of simplified intensive cropping systems associated with both economic and social pressure to abandon traditional agricultural methods (Meeus, 1993).

4.2 Farmer behaviour in Africa

In sub-Saharan Africa, large families are associated with prestige, and social pressures therefore contribute to the 3% annual increase in the human population (Hyden *et al.*, 1993). A dramatic reduction in the length of arable rotations, and therefore area of fallows, has resulted, in an attempt to increase food production. Because of the lack of fallow, soil fertility has declined (Reij *et al.*, 1996), necessitating larger areas of land to be brought into cultivation. Such changes in landuse have substantial effects on both people and birds using farmland. Fallow periods and management are also influenced by farmer aspirations and social status and family position through access to labour (Gleeve, 1996).

Gender issues can have substantial impacts on agricultural land management in sub-Saharan Africa, including Senegambia. In Mandinka communities with access to seasonally flooded land, men control usufruct rights to dryland rain-fed crops (e.g. millet and groundnuts (*Vignia subterranea*)), and the crops are managed by both men and women. Rights to rice (*Oryza* spp.) crops are owned by men and the crops are managed by women. Rights to vegetable gardens are normally controlled by women who also do all the work. Recent drought and urbanisation of many people has increased the market for vegetables and reduced the viability of rain-fed crops. These cultural norms now lead to considerable changes in the relative wealth of men and women, and the failure of men to perform their traditional role of meeting the costs of supplemental grain, clothing and religious and social ceremonies (Schroeder & Watts, 1991). The partial withdrawal of women from work on rain-fed crops has led to changes in the management of this land, including increased use of fire to clear bush, weeds and crop debris. Similar issues have affected tree planting on land where the relative control over land use by men and women is disputed (Schroeder, 1997).

Such differences in gender-related land rights in Senegambia are confined primarily to Mandinka communities and are certainly not universal. For example, Warren and Pinkston (1998) describe convergence of male and female roles in farming activities, and most recently in tree ownership, in response to economic and social forces in the Yoruba of southeast Nigeria. Differences between tribes within Senegambia include the relatively large size and intensive management of farms controlled by Tourca (Chapter 8), and the long-established incorporation of Acacia trees into the arable system adopted by Serer in central Senegal (Pélissier, 1966). In Mali, Ayers (1995) has shown that soil and water conservation techniques differ according to gender, class and ethnicity, while in Burkina Faso, cultural values rooted in ethnic differences also play an important role in land use (Reenberg & Paarup-Laurensen, 1997). In the latter case, social aspirations of Rimaibé (historically slaves) result in their cultivation of a disproportionately large area of light unproductive land compared with Fulbe (historically masters) because of the low social status associated with physical work on heavy, but more productive land.

Many African cultural landscapes include sacred groves of trees, often the perceived homes of ancestral spirits, and specific tree and other plant species are managed and maintained specifically for similar spiritual and religious reasons (Falconer, 1999; Laird, 1999; Zoundjihekpon & Dossou-Glehouenou, 1999). African cultures do not distinguish between spiritual, medicinal and food values of plants in the same way that Europeans do (Iwu, 1999). This culture is reflected in indigenous languages and attitudes to wildlife, its value and management, and can change as local languages are subsumed by majority languages which lack appropriate vocabularies (Maffi, 1999). Warren and Pinkston (1998) describe how domination of traditional cultures by Christianity and Islam have reduced the value placed on sacred groves and individual plant species. They report 330 plant species in one surviving sacred grove which supported only 23 species on its perimeter where the ecosystem had been disturbed by human activity.

The relative role of the individual and the community also differs between many northern and southern cultures, as indicated in Crane's (1994) comparison between middle-class Americans and upper-caste Hindu Indians. In this case, differences in identity are exaggerated by language. For example, the relative importance of the individual and community may be more apparent in the expression of values and actions than in actual behaviour, or in the motives that determine that behaviour. Schroeder (1997) documented how, in a dispute between Gambian Mandinka men and women over the competing interests of rice harvesting and vegetable garden cultivation, male leaders expressed their own interests in terms of community benefits, thereby attempting to stigmatise the women. In America, Sullivan *et al.* (1996) have found that organic farmers express a greater perception of community than those farming conventionally.

4.3 Farmer behaviour in Europe

Eder (1996) describes how attitudes to environmental issues in Europe are an amalgam of subjective aesthetic, social (moral), and objective empirical (scientific) judgements. Perceptions of environmental risks, and proposed action to prevent or alleviate them therefore depend on moral commitments to particular "cultural filters" (Macnaghten & Urry, 1998). As with traditions and fashions, these may change with time. Current debates over environmental impacts of genetically modified agricultural crops (as with other biological issues such as cloning) are influenced strongly by subjective and moral values which challenge science and the communication of 'hard facts' (quantitative data), and by differences in scientific paradigms.

A feature of European/North American culture is the perceived nature/culture, wilderness/cultivation dichotomy (Ingerson, 1994; Eder, 1996), of which the strongest advocates maintain that farmland should not be regarded as a habitat for birds and other wildlife, but as an area for food production alone, non-farmed areas being used for conservation (e.g. Avery, 1995). Such an attitude is especially prevalent in North America. A similar dichotomy is expressed in the perception of wildlife as either pest or valued resource (MacDonald, 1984). Farmers often regard creating intensively managed 'clean' and 'tidy' farms as good environmental practice, although this rarely has conservation benefits (Aughney & Gormally, 1999). Oreszczyn & Lane (1999) identified both 'emotional' (personal) and 'rational' (professional) attitudes of individual farmers towards hedges on their farms. The view that arable landscapes can integrate food production, recreation and the conservation of wildlife within a single land management system is becoming increasingly accepted in Europe (Potts, 1991 & 1997; Tucker, 1997).

Farmers' attitudes in the 1980s were widely at odds with conservation objectives, with favourable attitudes towards hedge removal in order to improve farming efficiency (Carr & Tait, 1990 & 1991). Beedell & Rehman (1996), interviewing a sample of 30 farmers in Bedfordshire in 1994, reported a narrow view of 'wildlife' and little consideration of global issues and wider environmental problems. Conservation was perceived as expensive, time-consuming and separate from the farm business, and farmers were not receptive to advice on conservation issues. There were however, developing attitudes to farmers' role as 'guardians of the countryside', and Westmacott & Worthington (1997) reported that farmers have become more receptive to considering conservation and landscape judgements as part of their farming activities.

Following a questionnaire survey in England in 1995, the Countryside Commission reported that 91% of respondents agreed that "society has a moral duty to protect the countryside for future generations", and that 71% agreed that "farming keeps the countryside an attractive place" (Countryside Commission, 1997). However, only 26% of respondents felt that "laws from Brussels and Europe are likely to help conserve the countryside". Using two questionnaire surveys, Macdonald and Johnson (2000) have shown that a combination of farmers' own interests (especially game shooting – 64% of farms), and financial incentives from European and national subsidies can result in substantial environmental improvements on farmland. The proportion of farmers seeking professional advice on such management increased from 10% to 41% between the first survey in 1981 and the second in 1998, while the proportion who claimed to be "very interested" in wildlife increased from 40% to 62% over the same period.

The farming systems most strongly associated with otherwise threatened wildlife are often low-intensity systems which survive in some parts of Europe because of environmental constraints (McCracken *et al.*, 1995; Araújo *et al*, 1996), although their contribution to biodiversity is also dependent on the knowledge, attitudes and socio-economic status of farmers (Aughney & Gormally, 1999). Whereas, in the most productive farming areas, participation in conservation behaviour is inversely related to economic constraints (Gasson & Potter, 1988; Kazenwadel *et al.*, 1998), in more marginal areas, the reverse can be true (Battershill & Gilg, 1997, Wilson, 1996 & 1997b). Gasson and Potter (1988), in a survey of 145 farmers in three areas of lowland England, found that farm size and profitability had substantial influence on farmers' ability to adopt conservation management practices.

Battershill and Gilg (1997) found that, in southwest England, attitudinal dispositions of farmers were more important than their structural constraints. Similar findings are reported by Battershill and Gilg (1998) for traditional farming systems in northwest

France, and by Ilbery (1991) in the West Midlands. Wilson (1996) also highlights the importance to conservation behaviour of the interaction between attitudinal and structural factors in Wales. In southwest England "traditional" farmers were more likely than more "commercial" farmers to "associate their understanding of environmentally friendly farming with their definition of good husbandry" (Battershill & Gilg, 1996). In the Pevensey Levels (Sussex), some farmers explained their reluctance to convert wildlife-rich permanent pasture to arable (in spite of CAP incentives to do so) in terms of a moral imperative (Burgess *et al.*, 2000). For them, managing the area 'in tune with nature' was an expression of their cultural identity. Farmland hedges are also regarded by farmers and other groups in terms of identity and a 'sense of place' (Oreszczyn & Lane, 2000).

Battershill and Gilg (1997) reported that diversification into off-farm activities was associated with greater involvement in conservation. Ellis *et al.* (1999) found that farm and household characteristics, particularly involvement in off-farm activities, influenced botanical composition of grass swards on Scottish farms although they did not elaborate on the mechanisms by which this might have happened.

Farming systems maintained for the production of quality regional/cultural or other niche products, or for organic farming, may support more wildlife, although here too, farmers' environmental attitudes may have a greater influence on environmental benefits than the farming systems themselves (Entec, 1995; Sullivan *et al.*, 1996; Battershill & Gilg, 1998). This has important implications for the adoption of agri-environmental payments for such practices as organic farming and specific environmental management measures.

Farmers entering these schemes purely because of the economic incentives may be less likely to achieve environmental benefits than those sharing the aims of the schemes. Battershill and Gilg (1996) found that "traditional" farmers were more reluctant than more "commercial" farmers to participate in agri-environment schemes, although having done so, 56% said the schemes had had a positive effect on their attitudes to conservation. Morris (1993) (cited in Battershill & Gilg, 1996) argues that "a positive attitudinal impact is perhaps the most important long-term scheme effect".

Based on work with farmers considering participation in an agri-environmental scheme (Environmentally Sensitive Area) in the Sussex downs, Morris and Potter (1995) describe farmer behaviour in terms of a continuum from "non-adoption", through "passive adoption" to "active adoption". Active adopters already have positive attitudes towards conservation management and use the ESA scheme to continue or develop work they are already doing, while passive adopters participate in the scheme for purely financial reasons. The scheme therefore makes little difference to the behaviour of active adopters, while long-term conservation behaviour of passive adopters is unlikely to continue once the financial incentives are withdrawn, unless farmers' motives, values and attitudes change during the funding period. Morris and Potter (1995) argue for a "willingness to regard participation [in agri-environment schemes] as a training and learning experience rather than a series of conditions which must be complied with in order to secure a payment". In fact agri-environment schemes have the potential to fulfill both roles. The success of such an approach is dependent on an understanding of passive adopters' existing farming culture and on the development of this towards appropriate conservation behaviour.

Carr and Tait (1991), Lynne *et al.* (1995) and Beedell and Rehman (1999 & 2000) have shown that farmer behaviour can be influenced by the attitudes of others ('social norms') according to the Theory of Reasoned Action (Ajzen and Fishbein, 1980). In the Netherlands, van der Meulen *et al.* (1996) suggest that "confidence in the contact person is ... the most important aspect for participating in unsprayed crop edge projects", a fact also reported by Young *et al.* (1995). Adoption of organic farming has been found to be influenced more by information from other farmers, than from the press, buyers or professional advisors (Anon, 1999). Lowe *et al.* (1997) describe Devon dairy farmers' attitudinal changes to environmental pollution as people from different cultural backgrounds and with different environmental values join the rural community, and as younger farmers are influenced through the education system.

Subjective characteristics perceived by farmers, as well as the objective character of conservation actions, influence farmers' actual behaviour (McHenry, 1998; van der Meulen *et al.*, 1996). Wossink *et al.* (1997) claim that "farmers' subjective preferences for characteristics of weed control techniques are important determinants of adoption behaviour" and that "the conventional focus in technology development on agronomic characteristics is much too narrow". Formal analysis of behaviour has been extended to incorporate constraining factors over which the actor has little volitional control (the Theory of Planned Behaviour, Ajzen, 1985).

Naveh (1995) argues for more inclusive investigation of motives for behaviour, "bridging the gaps between bio-ecology and human ecology" and linking "quantitative formal approaches with qualitative descriptive approaches". Oreszczyn and Lane (1999 and 2000) describe how, although attitudes to hedge management differ considerably between farmers and public, "emotional views" are shared between these groups and are expressed by farmers in their management of certain hedges and other non-crop areas. However, such attitudes were not shared by conservation "experts" who took a narrow objective approach. Farmers may take account of these other groups in modifying their own perceptions and behaviour (e.g. Lowe *et al.*, 1997).

Social norms therefore interact with farmers' own perceptions and attitudes, and environmental constraints and opportunities, to influence their conservation behaviour, thereby contributing to revised values and the evolution of a new farmland management culture. Improved understanding of these complex processes, and effective application of that understanding to conservation issues, requires an interdisciplinary approach and the full participation of farmers in research. An interdiscplinary, participatory approach is therefore increasingly being adopted in the initial understanding of issues and subsequent development of environmental management on farmland (Pretty, 1994; Chambers, 1997; Warburton, 1997).

4.4 Interdisciplinary research

Interdisciplinary research involving a holistic (systemic) approach, and the full participation of farmers has, until recently, been adopted only on a very limited scale as it sometimes fails to meet the requirements of 'hard' science (e.g. statistical analysis of quantitative data) and is therefore confined to the margins of conservation research. As in other disciplines, journals with reputations for scientific quality often preclude publication of research adopting or incorporating alternative methods. As researchers' careers are influenced by their rate of publication, this inhibits wider adoption of interdisciplinary participatory methods (Ingerson, 1994), thereby acting as a "cultural filter", limiting available information and wider adoption. While a rigorously researched scientific understanding of ecological issues is essential to any further practical action, the process of defining the facts for hypothesis testing restricts investigation to what can actually be measured and limits the scope of investigation within culturally defined boundaries (Wynne, 1992; Eder, 1996).

Conservation research can be conducted, either in two stages, with ecological research being followed by research into socio-economic and cultural motivation for action, or the two can be integrated, with iterative feedback into a systemic research process. The latter avoids, for example, the development of conservation management options that are impractical or have no appeal to farmers. Within the field of agri-environmental management, and farmers' motivation for it, more inclusive research is therefore required (Morris & Potter, 1995; Young *et al.*, 1995).

Systemic, interdisciplinary and participatory methods have been rapidly and widely adopted in developing countries by NGO researchers concerned with major environmental problems, and with the development of practical measures for their alleviation (Chambers, 1997). More recently, an interdisciplinary, participatory approach has been adopted by some organisations involved with practical environmental management of the wider countryside in Britain (Warburton, 1997). "Conservation is now recognised to be a fully participative cultural activity, not solely the occupation of experts and not restricted in its application to the richest and rarest features of the countryside" (National Trust, 1995). Participatory projects conducted by the Countryside Commission (Warburton, 1997) include the design of community open space and community forests, and countryside character programmes to strengthen awareness and action on local distinctiveness. Other projects include traffic calming and improving the recreational value of minor roads, encouraging woodland that provides multiple public benefits, developing sustainable leisure activities, and increasing markets for rural products.

The success of the participatory approach has been attributed to its ability to bring new ideas and develop innovative approaches, and to release additional resources within communities, and local knowledge appropriate to individual situations (Warburton, 1997). It is also more sustainable, in that people are more likely to maintain a project if they have been instrumental in setting it up (e.g. Cooper *et al.*, 1997). Any set of decisions or regulations imposed externally on a large group of people is unlikely to suit them perfectly because motivation tends to be specific to local circumstances.

Participation also enables people to develop their own confidence and skills, and to break dependency links, while improving trust and understanding between public institutions where this is appropriate (Warburton, 1997).

Genuine participation therefore involves complete integration of "actors" into the learning process and tends to involve interdisciplinary methods that seek multiple perspectives (Pretty, 1994). However, participation can be conducted at a range of levels with differing local involvement and empowerment (Table 4.1). An advantage of the inclusive and interdisciplinary nature of the approach is that it is sufficiently flexible to address complex and diverse information, identify exceptions and explore variability (Chambers, 1997). In this way, the complexity of farmers' economic, environmental and cultural motivation for their adopted behaviour can be understood and management practices and systems can be advanced.

These principles are adopted as far as possible in the research presented in chapters 7 and 8. The methodology adopted at the whitethroat breeding and wintering sites differs in some important respects. Whereas the problem in the whitethroat's breeding region involves habitats and management practices which are well understood, involves farmers with cultural values that are similar to my own, and is well defined, none of these apply to the problem in the wintering region. In addition, farmers in the breeding region are consistently highly literate, while very few of those in the wintering range have basic writing skills. For these reasons, a written questionnaire with well-defined questions was appropriate for the British farmers, while a more flexible, verbal and symbolic approach was required in Senegambia.

The section on whitethroat breeding habitat management by farmers is exploratory, using a questionnaire to investigate the reasons for farmers' management, the relationship between their intended and actual behaviour, their attitudes towards various habitat components, and the influences on those attitudes. Farmers were involved in the design of the questionnaire and the results of the questionnaire will be used in a consultative process to improve the wider management of field boundaries on farmland to benefit both farmers and birds (although this stage in not incorporated in this thesis). The project is therefore equivalent to participatory level "3" in table 4.1.

The study then investigates farmers' motivation for the management of tree and shrub species used by whitethroats in their Senegambian wintering area. The work is highly interactive with farmers and is being used to develop action plans with multiple perspectives, and is therefore equivalent to a participatory level "6" in table 4.1. This study is the first to use participatory techniques to develop an understanding of farmers' management of a bird habitat in sub-Saharan Africa with a view to habitat improvement.

Table 4.1. Typology of participation: how people participate in development programmes and projects. Source: Pretty (1994).

	Typology	Components of each type
1	Passive participation	People participate by being told what is going to happen, or has already happened. It is a unilateral announcement by an administration or project management without any listening to people's responses. The information being shared belongs only to external professionals.
2	Participation in information giving	People participate by answering questions posed by extractive researchers using questionnaire surveys or similar approaches. People do not have the opportunity to influence proceedings, as the findings of the research are neither shared nor checked for accuracy.
3	Participation by consultation	People participate by being consulted, and external agents listen to views. These external agents define both problems and solutions, and may modify these in the light of people's responses. Such a consultative process does not concede any share in decision making, and professionals are under no obligation to take on board people's views.
4	Participation for material incentives	People participate by providing resources, for example labour, in return for food, cash or other material incentives. Much on-farm research falls into this category, as farmers provide the fields but are not involved in the experimentation or the process of learning. It is very common to see this called participation, yet people have no stake in prolonging activities when the incentives end.
5	Functional participation	People participate by forming groups to meet predetermined objectives related to the project, which can involve the development or promotion of externally initiated social organisation. Such involvement does not tend to be at early stages of project cycles or planning, but rather after major decisions have been made. These institutions tend to be dependent on external initiators and facilitators, but may become self-dependent.
6	Interactive participation	People participate in joint analysis, which leads to action plans and the formation of new local institutions or the strengthening of existing ones. It tends to involve interdisciplinary methodologies that seek multiple perspectives and make use of systematic and structured learning processes. These groups take control over local decisions, and so people have a stake in maintaining structures or practices.
7	Self-mobilization	People participate by taking initiatives independent of external institutions to change systems. Such self-initiated mobilisation and collective action may or may not challenge existing inequitable distributions of wealth and power.

4.5. Synthesis

The literature suggests that cultural and social factors, as well as climate, topography, soil type and political and trade policy can all combine to determine management of the farmland environment, and that these factors differ considerably between regions. While economic and structural influences on agricultural activity are well understood, little attention has been given to the cultural influences described in this chapter.

This review demonstrates that cultural factors have been, and continue to be a major influence on agricultural management practices, both directly, and less directly through the culture of food consumption and environmental appreciation. This applies in both breeding and wintering areas used by migratory species. Such cultural values are subject to evolution and therefore offer both opportunities and challenges in terms of conservation management on farmland. This thesis argues that an improved understanding (through participatory research) of cultural issues is crucial to the economically and environmentally sustainable management of the farmland environment. This is an innovative approach for two reasons:

- Cultural values are rarely accommodated in plans for wildlife conservation on farmland
- Conservation plans for migratory species rarely take account of both breeding and wintering areas simultaneously

These issues are investigated in the following chapters.

The role of game management in the conservation of farmland passerines

This section is based on research conducted in 1992-1998 and is presented in the form of a single paper published in Bird Study 48 (2001). The format adopted by Bird Study is therefore also adopted within this thesis in order to distinguish this chapter from unpublished chapters. The paper describes my own research into the impact of a game management system on a breeding bird community in Leicestershire. The study species are blackbird, song thrush, dunnock, whitethroat, chaffinch and yellowhammer.

An appendix has been added on the implications of the findings for bird species diversity.

Chapter 5

Could game management have a role in the conservation of farmland passerines?: A case study from a Leicestershire farm.

CHRIS STOATE and JOHN SZCZUR

The Game Conservancy Trust, Loddington House, Loddington, Leics. LE7 9XE.

The management of wild gamebirds for shooting involves a combination of habitat management (woodland, field boundaries and gamecrops), winter feeding and control of potential nest predators, any of which could benefit other birds, including nationally declining species associated with farmland habitats. Changes in numbers of passerines were monitored over six years in relation to game management on farmland in Leicestershire. Nest success was monitored over four years and, for some species, was inversely related to abundance of breeding corvids. Abundance of breeding passerines increased during the period of game management. Species whose breeding populations have declined nationally (coincident with agricultural intensification) showed the greatest increases in abundance relative both to other species, and to the same nationally declining species in nearby farmland. The precise mechanism by which the game management package contributes to increased breeding numbers is not understood and is likely to differ between species. However, these results show that further integration of wild game management into farming systems could have conservation benefits for nationally declining farmland birds.

5.1 INTRODUCTION

Birds associated with farmland habitats have declined in numbers since the 1970s, with these declines being attributed to changing farming practices associated with intensification and simplification of agricultural systems (O'Connor & Shrubb, 1986; Fuller *et al.*, 1995; Sirwardena *et al.*, 1998; Chamberlain *et al.*, 1999). Such intensification and simultaneous declines in bird numbers have been noted across most of Europe (Tucker & Heath, 1994). Species that have declined by 50% or more over the

1971-1995 period (Crick *et al.*, 1997) are given special conservation status (Red List species) and are currently the subject of Biodiversity Action Plans (Gibbons *et al.*, 1996).

A range of specific causes has been suggested for the declines. Potts (1986) demonstrated that a decline in chick survival of Grey Partridges *Perdix perdix* was a cause of the decline in breeding numbers of this species, and that depressed chick survival was a result of increased pesticide use and the resulting removal of essential chick food invertebrates. Brickle & Harper (2000) and Aebischer & Ward (1997) have shown that breeding success and abundance of Corn Buntings *Miliaria calandra* are positively related to abundance of Symphyta and Lepidoptera larvae.

The length of hedgerows, the habitat adopted by most farmland species during the breeding season, has declined in recent decades (Barr *et al.*, 1994), while simplification of cropping patterns has also reduced the suitability of farmland as a breeding habitat for some species by reducing spatial and temporal habitat diversity (Chamberlain *et al.*, 1999; Wilson & Browne, 1993). Numbers of Magpies *Pica pica*, a major predator of other passerine nests (Holyoak, 1993; Groom, 1993), have increased through the period in which numbers of potential prey species have declined (Fuller *et al.*, 1995; Gregory & Marchant, 1996), but no relationship has been found between increases in predators and declines in numbers of passerines (Thomson *et al.*, 1998).

The considerable use made of weedy cereal stubbles by farmland passerines in winter (Evans & Smith, 1994; Donald & Evans, 1994; Wilson *et al.*, 1996) suggests that the loss of this habitat as a result of improved herbicides and increased use of autumn-sown cultivars, could have contributed to declines in bird numbers through reduced winter food supply and survival. Chamberlain *et al.* (1999) reported a relationship between declines in numbers of farmland birds and a decline in the area of spring cereals, a crop associated with winter stubbles on light soils. Spring cereals also have a more open structure, a factor known to influence habitat selection and foraging behaviour of farmland birds (Odderskær *et al.*, 1997).

Incentives for farmers to adapt current farming practices to accommodate the ecological requirements of declining farmland birds take two forms, although these are not totally independent. One is economic, through agri-environment schemes that directly reward farmers who modify their farming systems, or through premiums paid in an open market for products of environmentally benign production methods (e.g. organic farming). The second is mainly cultural, in which farmers who are able and inclined to do so, manage habitats and adapt farming methods specifically for wildlife. In the majority of cases, such management is intended to increase autumn numbers of gamebirds for shooting, sometimes for economic reasons, but very often for social reasons (chapter 7). The number of farmers who are sufficiently interested in non-game wildlife to change their farming methods is relatively small and game interests are the major influence on conservation management (MacDonald & Johnson, 2000).

This paper investigates the potential of wild gamebird management for wider conservation of farmland birds, where Pheasant *Phasianus colchicus* is the game species. Management of a wild Pheasant population differs from that of birds reared artificially in that the wild birds' ecological requirements must be met throughout the year. In winter this species requires small shrubby woods, patches of dense cover in more open habitats, and cereal grains as food. In the breeding season, it exploits farmland habitats where it requires tall herbaceous vegetation in which to nest and an abundance of ground-dwelling invertebrates close to the nest as a source of food for chicks. Hens with broods prefer to forage where vegetation is sufficiently open for chicks to move through easily, but has an overhead canopy to provide security from predators. As Tapper *et al.* (1996) demonstrated for Grey Partridge, control of potential nest predators during the nesting season increases the number of chicks hatching to exploit this food source. Table 5.1 summarises the management practices associated with the management of a wild gamebird population and their potential benefits to passerines.

All of the management practices described in Table 5.1 were adopted on the farm at Loddington (Leicestershire) in order to increase breeding densities and autumn numbers of wild Pheasants for shooting (Boatman & Brockless, 1998). This paper describes changes in breeding numbers of passerine species on this and neighbouring farmland throughout the game management period. We also investigated nest survival in relation to this management regime.

5.2 METHODS

5.2.1 Study areas

The study area comprised approximately 200 km^2 of mixed arable and livestock farms in Leicestershire. The area consists of arable fields and grassland enclosed by hedges, and numerous small woods. Soils were mainly heavy clay. Within this area, transects (see below) were used to sample breeding abundance of birds in four discrete zones (Figure 5.1). The main study area, at Loddington, was located at the centre of the wider study area and covered an area of 3.33 km^2. Two additional areas (Horninghold (1.44 km^2)) and Owston (1.96 km^2)) were used specifically for the nest survival aspect of the study during 1995-1998.

The farm at Loddington is owned and managed as a research and demonstration farm by the Allerton Research and Educational Trust. Of the two sites in the surrounding area, Horninghold was selected at a 5-km distance along a random bearing from the centre of Loddington, and the Owston study site was selected at a similar distance along a bearing 180° from the first (Figure 5.1). Game management at Loddington started in 1993 (Table 5.1), following a year of baseline monitoring. At Horninghold and Owston no game management was practised. However, in 1997 Magpies were removed from Horninghold (by a landowner), and in 1998 Magpies were removed from both Horninghold and Owston, with Carrion Crows *Corvus corone* also being removed from Owston. Other forms of management remained constant at each site throughout the nest monitoring study.

5.2.2 Breeding bird abundance

The breeding abundance of Magpies and Carrion Crows at all three sites was monitored using annual nest counts in May. At Loddington, where game management began in 1993, territory mapping (Marchant *et al.*, 1990) in May and June was used to determine numbers of other breeding birds in 1992 and 1998. In each year ten visits were made to all parts of the farm, eight in the early morning and two in the evening. Bird behaviour and location for all species were recorded on maps for each visit. A combination of territory mapping and nest finding was used to determine breeding abundance of Song Thrushes *Turdus philomelos* as territory mapping alone is known to be a poor indicator of abundance (Snow, 1965). The authors were responsible for the monitoring of all species in all years and were experienced in this work before the project started.

In the years 1992-1998, transect counts, totalling 11.5 km in length, across all habitats at Loddington were used to provide an abundance index for each species. Transect counts were conducted in fine weather in May and early June, in the first three hours after dawn, four counts being conducted each year. All adult passerines seen or heard were recorded, except those in flight. Transect routes covered habitats with well defined boundaries and were constant between visits and years. Changes in breeding abundance were compared with data for the same period from four local Common Birds Census sites located within a 30-km radius of Loddington.

Table 5.1. Game management practices and their potential benefits to passerines

Ecological objectives for gamebirds	**Game management practice**	**Description of management**	Potential benefits to passerines
Breeding density	Supplementary feeding.	Provision of grain by hand and hopper from October to May.	Winter food sources for omnivorous and granivorous species (e.g. Yellowhammer, Stoate & Szczur, 1997).
	Provision of nesting cover.	Maintenance of herbaceous field boundary vegetation and planting of cover crops.	Nesting cover for Whitethroat, Yellowhammer etc (Stoate, 1999)
Nesting success	Predator control.	Control of Brown Rats *Rattus norvegicus*, Foxes *Vulpes vulpes*, Weasels *Mustela nivalis*, Stoats *M. erminae*, Carrion Crows and Magpies from April to July, by trapping and shooting.	Improved nest survival of some species.
	Nesting cover.	Maintenance of herbaceous field boundary vegetation and planting of cover crops.	Nesting cover for Whitethroat, Yellowhammer etc (Stoate, 1999)
Chick survival	Selective insecticide use. Conservation headlands. Brood-rearing crops.	Insecticides used on crops only when pest thresholds are exceeded, and target-specific insecticides are used. Reduced, selective use of herbicides and insecticides in field headlands. Planting of cereal-based, cover crops supporting high invertebrate densities.	These practices increase abundance of invertebrates which represent an essential food source for most passerines (e.g. Corn Bunting, Brickle & Harper, 2000).
Winter densities	Woodland management.	Planting new woods and maintenance of mature woodland with shrub layer and shrubby edge.	Woodland shrubs provide breeding habitat for Blackcap, Willow Warbler etc.
	Hedgerow management.	Maintenance of numerous, normally large hedges.	Passerine abundance and species diversity increase with hedge length and structural diversity (Arnold, 1983; Green *et al.*, 1994).
	Gamecrops.	Planting of annual, biennial or perennial crops to provide food and cover.	Gamecrops are exploited as a food source by passerines in winter (Boatman *et al.*, 2000).
Winter survival	Supplementary feeding	Provision of grain by hand and hopper from October to late April.	Winter food sources for omnivorous and granivorous species (e.g. Yellowhammer, Stoate & Szczur, 1997).

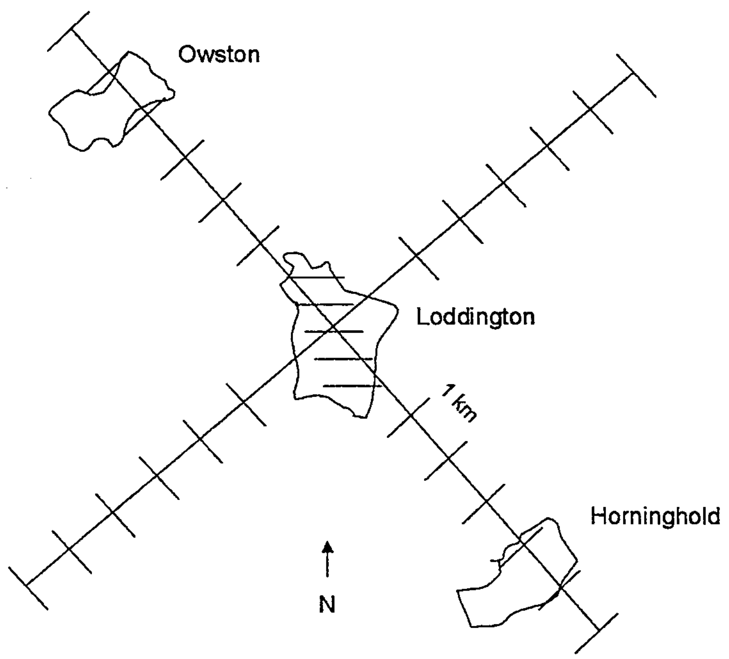

Figure 5.1. Location of 1-km transects along bearings radiating from the centre of Loddington, and of the two comparison nest monitoring sites.

In the years 1995-1997, separate transect counts were used to compare breeding bird abundance at Loddington with that in the surrounding area. For this, 1-km long distance sampling transects (Buckland *et al.*, 1993; Laake *et al.*, 1993), were conducted within Loddington, and at 1-km intervals along bearings radiating out from the centre of Loddington. The first bearing was selected at random, with subsequent bearings at 90°, 180°, and 270° from this (Figure 5.1). Transects were walked in May in the first three hours after dawn.

5.2.3 Nest success

Nest monitoring was conducted at Loddington, Horninghold and Owston from 1995 to 1998, from early April to late July each year, covering most of the breeding period for each of the species studied. Sampling effort covered all field boundary and woodland habitats and was constant between years. We selected species that were present in sufficient numbers in our study area to provide adequate sample sizes for nest survival analysis. The species are Blackbird *Turdus merula*, Song Thrush, Dunnock *Prunella modularis*, Whitethroat *Sylvia communis*, Chaffinch *Fringilla coelebs* and Yellowhammer *Emberiza citrinella*. The six study species are all open 'cup-nesting' species, but vary in their choice of nest site. While four nest in trees or shrubby vegetation, all Whitethroats and most Yellowhammers nest in herbaceous vegetation. With the exception of Song Thrush at Owston, all species were present at each of the three sites.

Nests were located by a combination of cold searches and observations of breeding birds. They were marked with a wide range of naturally occurring objects such as sticks and stones so as not to attract the attention of nest predators. Vegetation disturbed while visiting nests was readjusted as far as possible following the visit, although nest visiting by experienced fieldworkers is thought to have minimal impact on nest success (Mayer-Gross *et al.*, 1997) and any bias associated with possible increased predation would apply equally to all three study sites. Nests were visited at 3-7 day intervals. The number of eggs, number of young and their growth stage were recorded on each visit. Predation was assumed to have occurred if the contents of the nest had been removed since the previous visit, or if clear signs such as broken egg shells or partially eaten young were visible. It was rarely possible to determine the identity of nest predators from signs left at the nest. Causes of nest failure other than predation could generally not be determined with any certainty. Variables recorded included nest height above ground, and nest concealment (a subjective three-point scale of 'well hidden', 'part hidden' and 'exposed'). For Blackbird and Song Thrush, nest concealment was further assessed in 1997 and 1998 using the ratio of light meter readings at the nest and outside the bush in which the nest was located. In addition, meteorological data, comprising average daily temperature (mean of minimum and maximum) and daily rainfall, were provided by the Harold Martin Botanical Gardens located approximately 12 km west of our study area.

In 1996 two imprint-receptive dummy eggs made of Plasticene, coloured to resemble eggs of Blackbirds, were wired into 20 Blackbird nests that had already been depredated. Imprints left in these eggs following subsequent attempts at predation enabled the identity of nest predators to be determined. Although resembling more closely deserted than active nests, this approach approximates as far as practically possible, real nests available to predators in the study area.

5.2.4 Statistical analysis

For the most abundant species, estimates of breeding bird density at Loddington, and in the area surrounding Loddington, were determined from transect distance sampling data using the program DISTANCE (Buckland *et al.*, 1993; Laake *et al.*, 1993).

A hazard rate model with cosine adjustments (Buckland *et al.*, 1993) was selected by the program for Whitethroat, and a uniform model with cosine adjustments (Buckland *et al.*, 1993) for the other species.

Abundance of nationally declining and non-declining species for the 1992-1998 period from local CBC sites were pooled for comparison with data from Loddington after first correcting to an arbitrary baseline index of 100 in 1992. For more systematic comparison of abundance, based on random sampling of the surrounding area in 1995-1997, species were allocated to one of three groups: Red List species (national declines of more than 50% over 25 years), other declining species (national declines of less than 50%), and non-declining species (Crick *et al.*, 1997). These three groups formed the basis for comparisons of bird abundance between Loddington and the surrounding area using contrast analysis.

To avoid positive bias associated with locating a disproportionately large number of successful nests, estimation of the daily probability of nest survival was based on the method of Mayfield (1975). We used an extension of this method (Aebischer, 1999) to enable us to examine nest survival rates in relation to continuous and categorical variables.[A] Genstat 3.2 (Payne *et al.*, 1987) was used for these nest survival analyses.

This analysis was used to test for effects of Carrion Crow and Magpie abundance and other variables at each nesting stage for each species. These non-corvid variables included month of observation, the three-point nest concealment score, nest height ($\log_{10}$ (x+1) transformed to normalise the distribution of residuals) and means (for the five-day period preceding success or failure) for rainfall (log-transformed) and temperature, as well as covariates for year and site.

Daily nest survival rates calculated for each nesting stage were combined to give an overall nest survival rate (proportion of initiated nests surviving to fledge one or more young) for each site and year. Assumed duration (days) for incubation and nestling stages respectively, for each species, were Blackbird (14,13), Song Thrush (14,13), Dunnock (11,11), Whitethroat (11,11), Chaffinch (11,11) and Yellowhammer (11,10). The relationship between these overall nest survival rates and breeding densities of Carrion Crow and Magpie was then assessed using Pearson's correlation, and regression slopes calculated. Regression models incorporating all habitat and meteorological variables were then used to predict a second set of overall survival rates for each site and year, adjusted for factors other than Carrion Crow and Magpie abundance. The relationship between the resulting overall nest survival rates and breeding densities of Carrion Crows and Magpies was then assessed using Pearson's correlation as before.

5.3 RESULTS

5.3.1 Breeding bird abundance

Removal of Carrion Crows and Magpies at Loddington resulted in a substantial reduction in breeding density of both species and their abundance at Loddington was consistently lower than in the surrounding area in the 1995-1997 period (Table 5.2; Figures 5.2 & 5.3). Five of the study species increased in numbers during the study period, with Blackbird and Song thrush showing the greatest increases, as revealed by both territory mapping and annual transects (Figure 5.2). Breeding densities in the period 1995-1997 were higher at Loddington than in the surrounding area for all study species and years except for Whitethroat in 1996 (Figure 5.3).

Nationally declining species increased in numbers at Loddington over the 1992-1998 period (r_6 = 0.87, P=0.012), while the increase in abundance of non-declining species was not statistically significant (r_6 = 0.66, ns). These abundance data are presented in Figure 5.4. Over the 7-year period, nationally declining species abundance was significantly higher at Loddington than the index derived from pooled data from the four CBC sites (lacking game management) where there was no increase in abundance (r_6 = 0.08, ns; t_6 = 3.95, P<0.01; Figure 5.4). During the 1995-1997 period, in which more systematic local data were gathered, breeding abundance was higher at Loddington than in the average of the four zones in the surrounding area for red list species (Contrast analysis, $F_{1,10}$ = 5.19, P<0.05), and for other nationally declining species ($F_{1,10}$ = 9.73, P<0.05), but not for non-declining species ($F_{1,10}$ = 0.04, ns).

5.3.2 Nest survival

Predation was the major proximate cause of nest failure for all six species (Table 5.3). Of 20 depredated Blackbird nests fitted with imprint-receptive dummy eggs, 15 were depredated over a 12-day period. Corvids were identified as the nest predator in 14 cases, and Wood Mouse (*Apodemus sylvaticus*) in the remaining one. Across the three sites and four years, Blackbird and Song Thrush most often experienced the lowest nest survival, with highest nest survival being found for Dunnock and Whitethroat (Table 5.3).

For overall nest survival rates there was a negative correlation between nest survival rate and Carrion Crow breeding density for all species, this relationship being significant for Blackbird, Song Thrush, Dunnock and Yellowhammer. A negative relationship between overall nest survival rate and Magpie density was also apparent for all species except Whitethroat, and was significant for Blackbird and Song Thrush (Table 5.4, Figure 5.5). After allowing for

Table 5.2. Corvid breeding abundance based on nest counts (nests per km^2) in May, 1995-1998.

	Carrion Crow			Magpie		
	Horninghold	Owston	Loddington	Horninghold	Owston	Loddington
1995	3.47	3.06	0	2.08	5.1	0
1996	2.78	2.04	0	1.39	6.12	0
1997	2.78	5.1	0	0	4.59	0
1998	3.47	0	0	3.47	0	0

Table 5.3. Number of nests monitored over all sites and years, and causes of nest failure (% observed nests)

	Blackbird	Song Thrush	Dunnock	Whitethroat	Chaffinch	Yellowhammer
Number of nests	951	273	274	151	427	277
Successful (%)	38.7	47.1	62.7	71.8	39.3	51.8
Depredated (%)	54.7	41.2	30.2	21.5	50.7	37.1
Other failures (%)	6.6	11.8	7.2	6.7	9.9	11.2
Mayfield survival Estimate (±se)	22.2 ± 2.18	28.4 ± 3.74	51.1 ± 5.06	63.6 ± 4.85	33.1 ± 4.70	40.9 ± 4.63

Table 5.4. Pearson coefficients of correlation between corvid breeding density and average nest survival rates at each site in each year, before and after adjustment to take into account habitat and meteorological variables.

	Not adjusted for non-corvid variables		Adjusted for non-corvid variables	
	Carrion Crow	Magpie	Carrion Crow	Magpie
Blackbird	-0.786 **	-0.626 *	-0.769 **	-0.584 *
Song Thrush	-0.904 **	-0.751 *	-0.945 **	-0.694
Dunnock	-0.653 *	-0.348	-0.592 *	-0.342
Whitethroat	-0.396	0.164	0.140	0.477
Chaffinch	-0.172	-0.304	-0.139	-0.267
Yellowhammer	-0.821 **	-0.353	-0.794 **	-0.420

* $P<0.05$ ** $P<0.01$

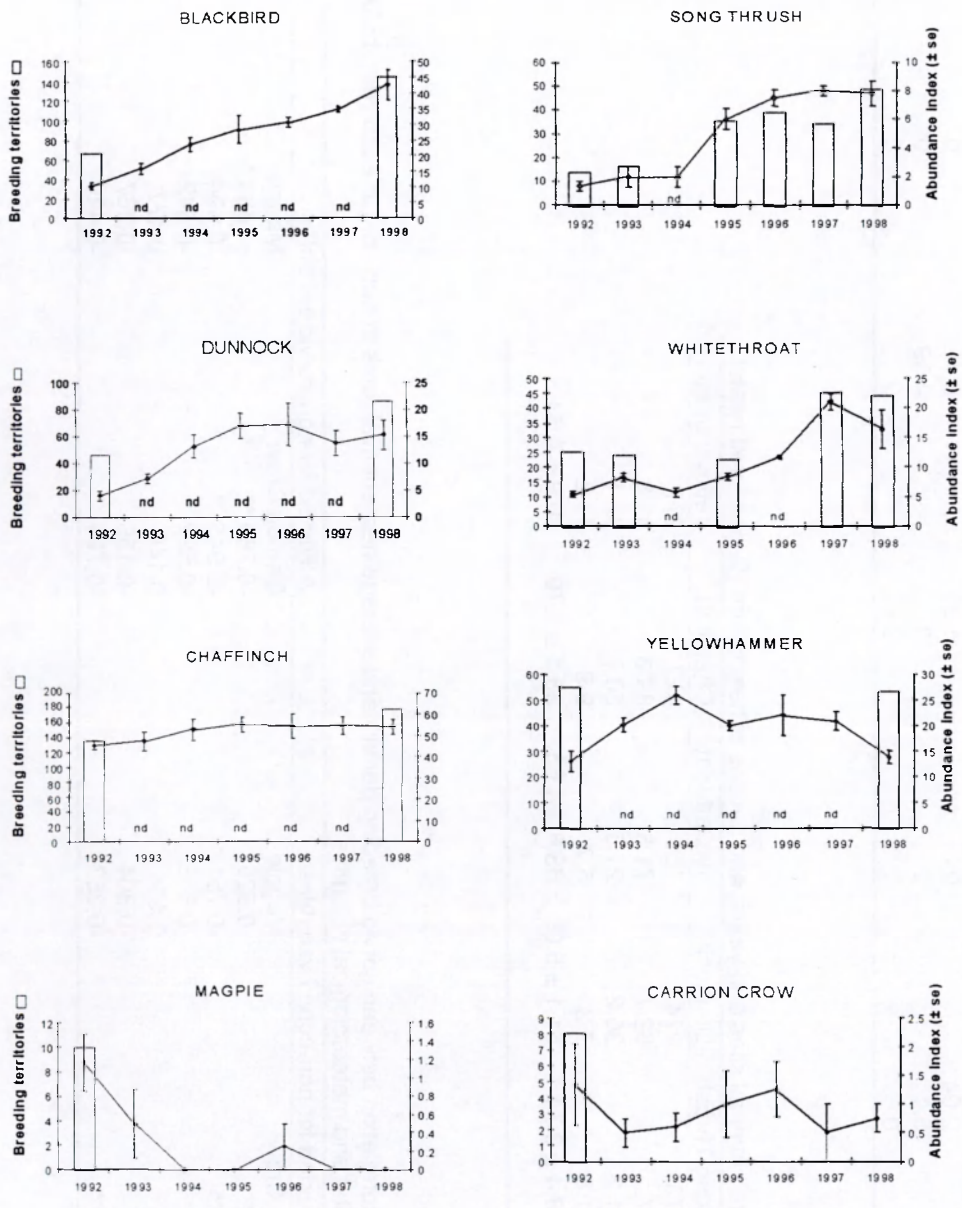

Figure 5.2. Changes in abundance of six farmland passerine species and two corvid species at Loddington (1992-1998), based on territory mapping (bars) and annual transects (lines; means ± se). nd = no territory mapping data.

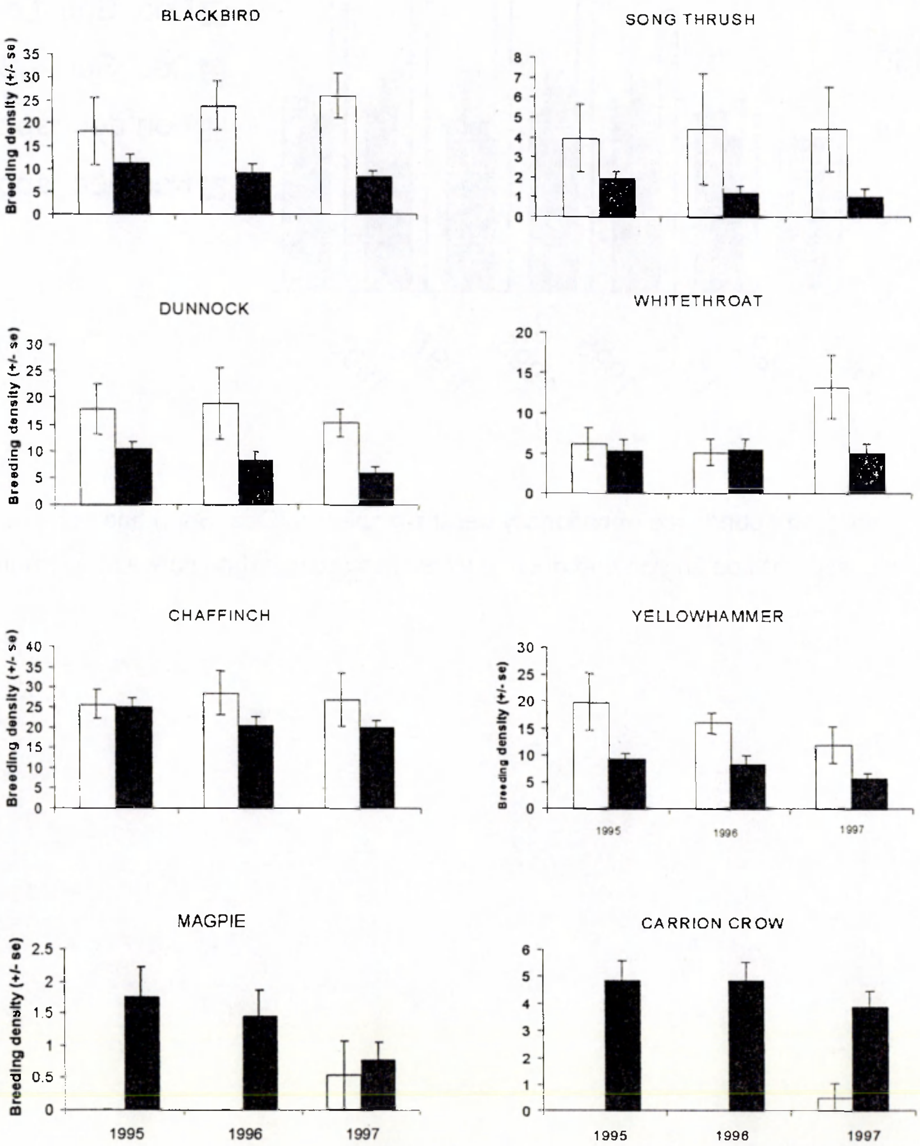

Figure 5.3. Relative densities (km^{-2} $\pm$ se) of six farmland passerine species and two corvid species at Loddington (white) and in the surrounding area (black) in 1995, 1996 and 1997.

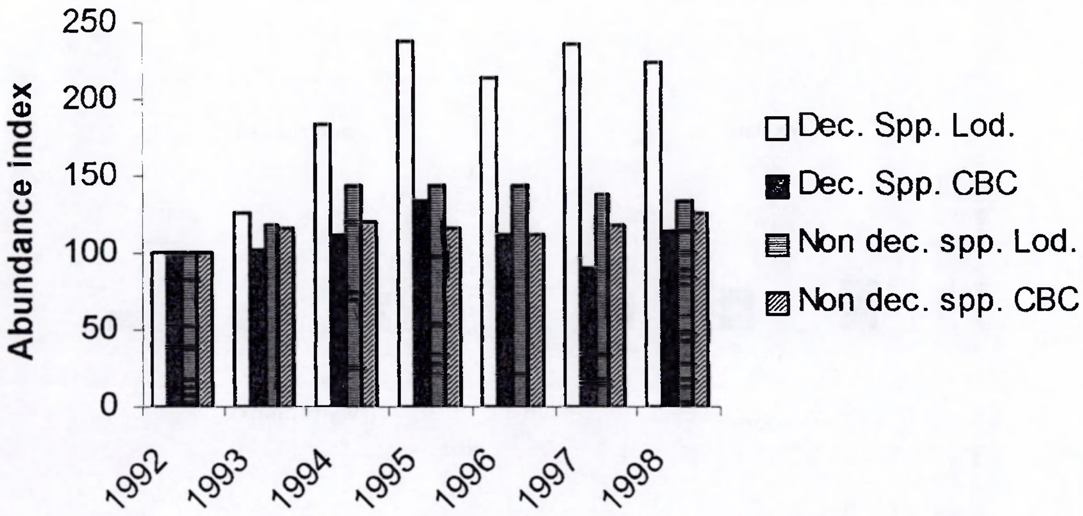

Figure 5.4. Changes in abundance of nationally declining species (Dec. Spp.) and non-declining species (Non dec. spp.) at Loddington and at other local sites (pooled data derived from four CBC plots).

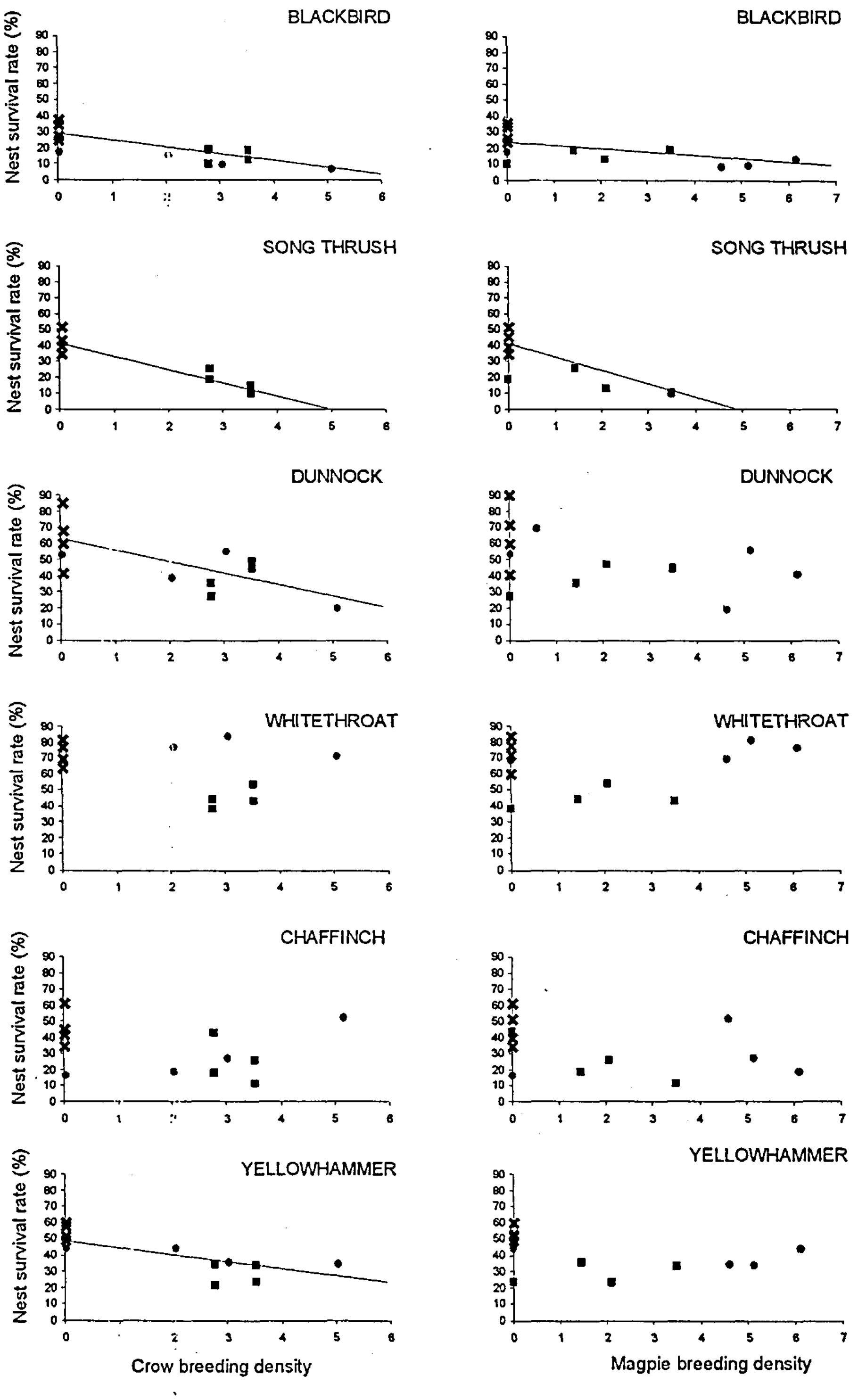

Figure 5.5. Relationship between nest survival of six farmland passerine species and the breeding density (km^{-2}) of Carrion Crows (left) and Magpies (right). Symbols represent study sites: Horninghold (■) Owston (●) Loddington (✖).

habitat and weather effects, the negative correlation between nest survival rate and corvid abundance was maintained for all species except for that between Whitethroat nest survival and Carrion Crow abundance; of the previously significant correlations only that between Song Thrush and Magpie ceased to be so.

5.4 DISCUSSION

Bird species which have declined nationally since the 1970s were the species to show the greatest increases in abundance at Loddington during the period of game management. These increases were not recorded at the local CBC sites lacking game management over the same period. These results suggest that the package of management practices associated with wild game management has considerable potential for the conservation of passerines on farmland. The mechanisms by which such management operates are not completely known, and are likely to vary between species.

For both migratory and sedentary farmland passerines, winter mortality could be an important factor determining breeding abundance (Baillie & Peach, 1992; Peach *et al.*, 1999). In the case of sedentary species the loss of weedy winter cereal stubbles from modern arable systems is likely to have reduced food availability for seed-eaters, with consequent increases in mortality. Annual and biennial seed-bearing gamecrops provide alternative food for farmland seed-eaters (Stoate & Szczur, 1997; Boatman *et al.*, 2000). Gamecrops, and the provision of cereal grains for gamebirds by hand feeding and hoppers, are therefore likely to improve over-winter survival of some species, with possible consequences for subsequent breeding abundance. Birds may also enter the breeding season in better condition than where supplementary food is not available, resulting in earlier nesting or larger eggs or clutch size.

For Yellowhammer and Whitethroat, herbaceous vegetation in field boundaries is known to influence territory establishment (Stoate, 1999) and this habitat has been maintained as a gamebird nesting habitat and as a habitat for beneficial invertebrates at Loddington. Other management of breeding habitat, such as thinning of woodland, could also have influenced directly the breeding densities of other species. Both recruitment of young birds to the breeding population and immigration of birds from other sites may have contributed to increased breeding densities in these modified habitats. Equally, recruitment to breeding populations in the area surrounding Loddington may be increased by higher productivity associated with the game management package.

Our study species differed substantially in their nest survival rates. However, for all species, predation caused more nest failures than all other causes combined. The use of plasticene eggs suggested that corvids were a major nest predator in this study and a consistent, although not always significant, negative relationship between overall nest survival and the abundance of the two corvid species remained, even after removing the effect of habitat and meteorological variables. Our results are consistent with those of Paradis *et al.* (2000), whose large-scale study of Blackbird and Song Thrush reproductive output revealed a negative impact of corvids. Removal of Carrion Crows and Magpies as part of the management of a wild gamebird population is therefore likely to increase nest success of some passerine species.

Thomson *et al.* (1997) suggest that for Song Thrush, a species with high susceptibility to nest predation in our study, first-year over-winter losses alone explain changes in breeding abundance at the national scale. For this and other species, declines in breeding populations have coincided with increases in nest success (Crick *et al.*, 1997) and no link between nest predation and subsequent breeding abundance have been demonstrated. There is also potential for an influence on breeding abundance of post-fledging survival or number of annual breeding attempts per pair, but these aspects require investigation (Siriwardena *et al.*, 2000). The extent to which such increases in nest success contribute to increases in breeding abundance is not known and may be complicated by varying environmental factors. For example, increased autumn densities could result in increased winter mortality if food supplies remain constant and mortality is density dependent. However, in a game management system, winter food supplies are increased at the same time as increased productivity, and increased winter mortality seems unlikely. The *package* of management practices, designed to increase both autumn and spring densities of wild gamebirds, is likely to have the same effect on other wild species.

This study has been limited to a single area. As well as differences between species within an area, the ecology of single species is likely to differ between areas, for example through different predator communities, abundance of their alternative prey, nesting habitat structure and availability, and abundance and availability of food, both in winter and in the breeding season. In addition, dispersal distances and direction area are likely to be influenced by characteristics of the surrounding area, as well as to habitat changes within an individual study area (Baillie *et al.*, 2000). These potential influences require further investigation.

The contribution of predator control to increases in passerine breeding densities remains contentious. Our results suggest that, at the farm scale, or where populations have declined for other reasons, increased nest success resulting from reduced predator abundance should be considered as a potential influence on increases in breeding numbers. The importance of predator control to the management of wild gamebird populations is well established (Tapper *et al.*, 1996), and our results suggest that, through such game management, shooting interests could contribute to the conservation of currently declining birds. Some of the management practices originally developed for the maintenance of wild gamebirds could be implemented independently of shooting interests under current Agri-environment options. However, for the taxpayer, coupling these economic incentives with the shooting interests of individual farmers would be a more cost-effective mechanism for bird conservation in many areas.

Despite the uncertainty over precise causal mechanisms determining abundance of breeding passerines at Loddington, our results suggest that game management has a role in the conservation of farmland passerines, and that that role is greatest for species which have declined nationally in response to simplification and intensification of farming systems. This is compatible with current moves away from production-linked payments to environmental and rural development measures, and to calls for diversification and integration of rural resources.

5.5 ACKNOWLEDGEMENTS

The farm at Loddington is owned and managed by the Allerton Research and Educational Trust and the work was funded by the Game Conservancy Trust, the Ernest Cook Trust, the Habitat Research Trust and the Whitley Animal Protection Trust. We also thank the many farmers in the wider study area for access to their land. We are grateful for discussions during the project, and for comments on the manuscript, to Nicholas Aebischer, Nigel Boatman, Jeremy Wilson, Jeremy Greenwood, Stephen Tapper, Nick Sotherton and Dick Morris. Peter Vickery and Gavin Siriwardena also helped to improve the manuscript. Data at local CBC sites were collected by T. Mitcham, G. Atkin, E. Coles, and members of the Leicestershire and Rutland Ornithological Society. Malcolm Brockless carried out winter feeding, predator control and much of the habitat management at Loddington. The Harold Martin Botanical Gardens provided meteorological data.

5.6 REFERENCES

Aebischer, N.J. (1999) Multi-way comparisons and generalised linear models of nest success: extensions of the Mayfield method. *Bird Study* **46** supplement, 22-31.

Aebischer, N.J. & Ward, R.S. (1997) The distribution of corn buntings *Miliaria calandra* in Sussex in relation to crop type and invertebrate abundance. In: Donald, P.F. &

Aebischer, N.J. (eds.) *The ecology and conservation of corn buntings* Miliaria calandra. JNCC, Peterborough. 124-138.

Arnold, G.W. (1983) The influence of ditch and hedgerow structure, length of hedgerows, and area of woodland and garden on bird numbers on farmland. *Journal of Applied Ecology* **20**, 731-750.

Baillie, S.R. & Peach, W.J. (1992) Population limitation in Palaearctic-African migrant passerines. *Ibis* **134**, 120-132.

Baillie, S.R., Sutherland, W.J., Freeman, S.N., Gregory, R.D. & Paradis, E. (2000) Consequences of large-scale processes for the conservation of bird populations. *Journal of Applied Ecology* **37**, 88-102.

Barr, C., Gillespie, M. & Howard, D. (1994) *Hedgerow Survey 1993 – stock and change estimates of hedgerow length in England and Wales.* 1990-1993. Institute of Terrestrial Ecology, Grange-over-Sands, Cumbria.

Boatman, N.D. & Brockless, M.H. (1998) The Allerton Project: Farmland management for partridges (*Perdix perdix, Alectoris rufa*) and pheasants (*Phasianus colchicus*). *Gibier Faune Sauvage* **15**, 563-574.

Boatman, N.D., Stoate, C. & Watts, N. (in press) Practical management solutions for birds on lowland arable farmland. *Ibis suppl.*

Brickle, N. & Harper, D. (2000) The ecology of corn buntings *Miliaria calandra* on lowland farmland. *Ibis supplement.*

Buckland, S.T., Anderson, D.R., Burnham, K.P. & Laake, J.L. (1993) *Distance Sampling*. Chapman & Hall, London.

Chamberlain, D.E., Fuller, R.J., Shrubb, M., Bunce, R.G.H., Duckworth, J.C., Garthwaite, D.G., Impey, A.J. & Hart, A.D.M. (1999) *The Effects of Agricultural Management on Farmland Birds*. BTO Research Report 209. British Trust for Ornithology, Thetford.

Crick, H.Q.P., Baillie, S.R., Balmer, D.E., Bashford, R.I., Dudley, C., Glue, D.E., Gregory, R.D., Marchant, J.H., Peach, W.J. & Wilson, A.M. (1997) *Breeding Birds in the Wider Countryside: their conservation status (1971-1995).* BTO Research Report 187. BTO Thetford.

Donald, P. & Evans, A.D. (1994) Habitat selection by Corn Buntings *Miliaria calandra* in winter. *Bird Study* **41**, 199-210.

Evans, A.D. & Smith, K.W. (1994) Habitat selection of Cirl Buntings *Emberiza cirlus* wintering in Britain. *Bird Study* **41**, 81-87.

Fuller, R.J., Gregory, R.D, Gibbons, D.W., Marchant, J.H., Wilson, J.D., Baillie, S.R. & Carter, N. (1995) Population declines and range contractions among lowland farmland birds in Britain. *Conservation Biology* **9**, 1425-1441.

Gibbons, D., Avery, M., Baillie, S., Gregory, R., Kirby, J., Porter, R., Tucker, G. & Williams, G. (1996) Bird Species of conservation concern in the United Kingdom, Channel Islands and Isle of Man: revising the Red Data List. *RSPB Conservation Review* **10**, 7-17.

Green, R.E., Osborne, P.E. and Sears, E.J. (1994) The distribution of passerine birds in hedgerows during the breeding season in relation to characteristics of the hedgerow and adjacent farmland. *Journal of Applied Ecology* **31**, 677-692.

Gregory, R.D. & Marchant, J.H. (1996) Population trends of jays, magpies, jackdaws and carrion crows in the United Kingdom. *Bird Study* **43**, 28-37.

Groom, D.W. (1993) Magpie *Pica pica* predation on Blackbird *Turdus merula* nests in urban areas. *Bird Study* **40**, 55-62.

Holyoak, D.T. (1993) A comparative study of the food of some British Corvidae. *Bird Study* **15**, 147-154.

Laake, J.L., Buckland, S.T., Anderson, D.R. & Burnham, K.P. (1993) *DISTANCE User's Guide. Version 2.0.* Colorado Co-operative Fish and Wildlife Research Unit, Colorado State Iniversity, Fort Collins, USA.

MacDonald, D.W. & Johnson, P.J. (2000) Farmers and the custody of the countryside: trends in loss and conservation of non-productive habitats 1981-1998. *Biological Conservation* **94**, 221-234.

Marchant, J.H., Hudson, R., Carter, S.P. & Whittington, P. (1990) *Population Trends in British Breeding Birds.* BTO, Tring.

Mayer-Gross, H., Crick, H.Q.P. & Greenwood, J.J.D. (1997) The effect of observers visiting the nests of passerines: an experimental study. *Bird Study* **44**, 53-65.

Mayfield, H. (1975) Suggestions for calculating nest success. *Wilson Bull.* **87**, 456-466.

O'Connor, R.J. & Shrubb, M. (1986) *Farming and Birds.* Cambridge University Press, Cambridge.

Odderskær, P., Prang, A., Poulsen, J.G., Andersen, P.N. & Elmegaard, N. (1997) Skylark (*Alauda arvensis*) utilisation of micro-habitats in spring barley fields. *Agriculture, Ecosystems & Environment* **62**, 21-29.

Paradis, E., Baillie, S.R., Sutherland, W.J., Dudley, C., Crick, H.Q.P. & Gregory, R.D. (2000) Large-scale variation in the breeding performance of song thrushes *Turdus philomelos* and blackbirds *T. merula* in Britain. *Journal of Applied Ecology* **37**, 73-87.

Payne, R.W., Lane, P.W., Ainsley, A.E., Bicknell, K.E., Digby, S.A., Harding, S.A., Leech, P.K., Simpson, H.R., todd, A.D. Verrier, P.J. & White, R.P. (1987) Genstat 5 Reference Manual. Clarendon Press, Oxford.

Peach, W.J., Siriwardena, G.M. & Gregory, R.D. (1999) Long-term changes in over-winter survival rates explain the decline of reed buntings *Emberiza schoeniclus* in Britain. *Journal of Applied Ecology* **36**, 798-811.

Potts, G.R. (1986) *The Partridge: pesticides, predation and conservation.* Collins, London.

Siriwardena, G.M., Baillie, S.R., Buckland, S.T., Fewster, R.M., Marchant, J.H. & Wilson, J.D. (1998) Trends in abundance of farmland birds: a quantitative comparison of smoothed Common Bird Census indices. *J. Appl. Ecol.* **35**, 24-43.

Siriwardena, G.M., Baillie, S.R., Crick, H.Q.P. & Wilson, J.D. (2000) The importance of variation in the breeding performance of seed-eating birds in determining their popluation trends on farmland. *J. Appl. Ecol.* **37**, 128-148.

Snow, D.W. (1965) The relationship between census results and the breeding population of birds on farmland. *Bird Study* **12**, 287-304.

Stoate, C. (1999) The influence of field boundary structure on breeding territory establishment of Whitethroat *Sylvia communis* and Yellowhammer *Emberiza citrinella. Aspects of Applied Biology* **54**, 125-130.

Stoate, C & Szczur, J. (1997) Seasonal changes in habitat use by Yellowhammers *Emberiza citrinella* In: *Brighton Crop Protection Conference – Weeds*. 1167-1162.

Stoate, C., Morris, R.M. & Wilson, J.D. (submitted) Cultural ecology of Whitethroat (*Sylvia communis*) breeding habitat management by farmers: field boundaries in lowland England. *Journal of Environmental Management*

Tapper, S.C., Potts, G.R. & Brockless, M.H. (1996) The effect of an experimental reduction in predation pressure on the breeding success and population density of grey partridges (*Perdix perdix*) *Journal of Applied Ecology* **33**,

Thomson, D.L., Baillie, S.R. & Peach, W. (1997) The demography and age-specific annual survival of song thrushes during periods of population stability and decline. *J. Anim. Ecol.* **66**, 414-424.

Thomson, D.L., Green, R.E., Gregory, R.D. & Baillie, S.R. (1998) The widespread declines of songbirds in rural Britain do not correlate with the spread of their avian predators. *Proc. R. Soc. B* **265**, 2057-2062

Tucker, G.M. & Heath, M.F. (1994) *Birds in Europe: their conservation status.* Cambridge, UK. Birdlife International.

Wilson, J.D. & Browne, S.J. (1993) *Habitat selection and breeding success of skylarks* Alauda arvensis *on organic and conventional farmland.* British Trust for Ornithology, Thetford.

Wilson, J.D., Taylor, R. & Muirhead, L.B. (1996) Field use by farmland birds in winter: an analysis of field type preferences using resampling methods. *Bird Study* **43**, 320-332.

ENDNOTE

[A] We modelled nest outcome as a binary variable (0=failure; 1=success) by logistic stepwise regression, incorporating observation period (the time between nest discovery and either success or failure) as the binomial denominator. Laying, incubation and nestling stages of the nesting period were treated separately. Where nests failed between visits, failure was assumed to have occurred half-way between the penultimate and final visit. Where eggs hatched, or nestlings fledged between visits, the half-way point between visits was again assumed, unless the resulting timespan exceeded the known incubation or nestling period for the species concerned when periods derived from the literature were substituted. The change in residual deviance resulting from removal of a variable from the model was used to test its significance against a χ^2 distribution with the appropriate degrees of freedom (Aebischer, 1999).

5.7 Appendix:

Game management and species diversity

The transect data collected at Loddington in the years 1992-1998, and the transect data from Loddington and the surrounding area for the years 1995-1997 were used to investigate the impact of game management on bird species diversity. Because sample size influences species diversity indices (Magurran, 1988), data from only the five first (innermost) transects in the surrounding area were used to compare with the five transects conducted within Loddington. The species diversity index used was that of Shannon and Wiener (Magurran, 1988). This index was compared between the four zones in the surrounding area using two-way ANOVA (zone x year) followed by contrast analysis (Loddington *v*. average of zones A-D), as in the comparison of bird abundance.

The Shannon Index of species diversity at Loddington increased from 1.10 in 1992 to an average of 1.16 in the 1995-1997 period, although this increase over the seven year period was not significant ($r_6 = 0.69$, n.s.) (Figure 5.6). There was no difference in species diversity between Loddington and the average across the four zones in the surrounding area.

The change in species diversity at Loddington following the introduction of game management and the subsequent difference between Loddington and the surrounding areas are both small. These results for species diversity suggest that the integration of game management into an otherwise conventional farming system may have limited potential for increasing bird species diversity at the farm scale. However, species diversity has not been widely used as a measure of avian biodiversity on farmland in Britain and the potential for a farm-scale increase beyond a value of 1.2 may be low.

More consistent temporal and spatial differences are recorded for the abundance of nationally declining species which increased at Loddington, and were then significantly more abundant there than on surrounding farmland lacking game management. Species that have maintained stable or increasing numbers nationally in recent decades showed smaller increases in abundance at Loddington. Integration of the wild game management package into a conventional farming system is therefore having greatest benefit, in terms of increased abundance, for the species of greatest national conservation concern. In this way, game management on farmland can contribute to national species diversity.

The poor response of local species diversity in relation to agricultural intensification is consistent with the results of Burel *et al* (1998), studying biodiversity in relation to agricultural landscapes in western France, and those of Araújo *et al.* (1996), studying bird abundance and species diversity in Portuguese farming systems. In the Portuguese study, farming systems with highest abundance of nationally threatened species were extensive arable-steppes with the lowest species diversity. In the Portuguese area, rare bird species and the botanically diverse habitats on which they depend contribute to a tourist industry and farmers are encouraged to adapt their crop management under the Agri-environment regulation (EC/2078/92). While a desirable goal in terms of conservation policy at the national level, species diversity could be a misleading indicator of the contribution to that goal made by adapted farm management systems at the farm scale.

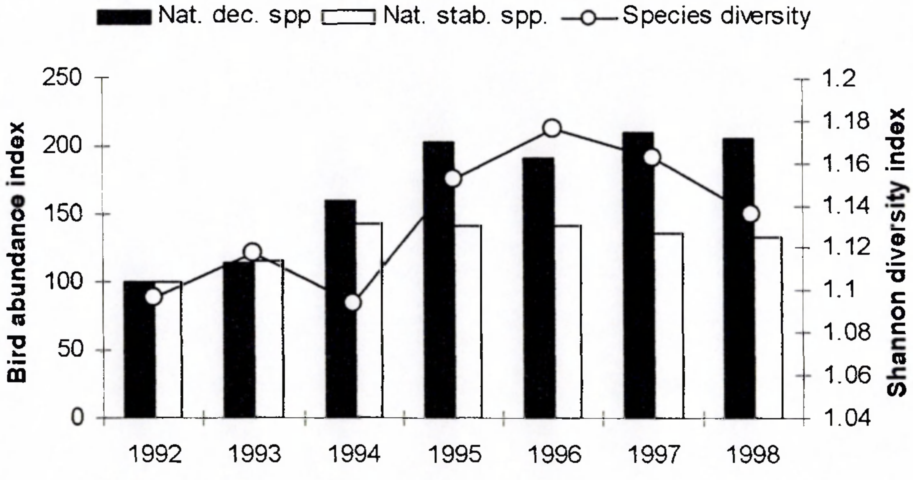

Figure 5.6. Breeding abundance of nationally declining songbird species (Nat. dec. spp.), and nationally stable or increasing species (Nat. Stab. Spp.) at Loddington during the period of game management (1993-1998), and the Shannon Index of species diversity over the same period.

Whitethroat habitat management

Chapter 6 includes research conducted in 1997 and is presented in the form of a paper published in Bird Study 48 (2001). As with chapter 5, the format adopted by Bird Study is used within this chapter in order to distinguish this chapter from unpublished chapters. This chapter investigates the influence of field boundary structure on territory establishment and nesting success of whitethroats and yellowhammers. An unpublished appendix has been added on a small-scale experimental study of nest predation.

Chapter 7 describes my unpublished research into farmers' management of the field boundary habitats used by whitethroats during the breeding season. Chapter 8 describes habitat use by whitethroats in the wintering area, and investigates the influences on farmers' management of that habitat.

Chapter 6

Whitethroat *Sylvia communis* and Yellowhammer *Emberiza citrinella* nesting success and breeding distribution in relation to field boundary vegetation

CHRIS STOATE and JOHN SZCZUR

The Game Conservancy Trust, Loddington House, Loddington, Leics. LE7 9XE. UK

Field boundary characteristics influencing territory establishment and nesting success of Whitethroats and Yellowhammers on farmland in Leicestershire were investigated. Hedge height had a negative influence on the presence of breeding Whitethroats. The abundance of herbaceous vegetation in field boundaries had a positive influence on both species. The relationship was strongest for Whitethroats which nested almost exclusively in herbaceous vegetation. Nesting success of Whitethroats was higher than that of Yellowhammers. Yellowhammer nests in hedges were more susceptible to predation than those in herbaceous vegetation. Maintaining low hedges and establishing uncut 2-m strips of perennial herbaceous vegetation in field boundaries would contribute to the conservation of Whitethroats and Yellowhammers on farmland.

6.1 INTRODUCTION

Whitethroats *Sylvia communis* and Yellowhammers *Emberiza citrinella* are widespread in Britain and are normally associated with farmland where they establish breeding territories in hedgerows. Both species were present at substantially lower numbers in the 1990s than in the 1960s (Crick *et al.*, 1997; Gibbons *et al.*, 1993). Although a range of factors is likely to have been responsible for the declines in breeding numbers of the migratory Whitethroat (Baillie & Peach (1992), and the sedentary Yellowhammer (Kyrkos, 1997), the loss of field boundary hedges over the same period (Barr *et al.*, 1994; Wesmacott & Worthington, 1997) could have contributed to recent depressed numbers. In the case of Whitethroat, evidence for this is provided by the fact that breeding numbers have recovered more in riparian habitats than on farmland where they were formerly common (Crick *et al.*, 1997).

Field boundaries comprise a combination of features including the shrubby vegetation of the hedge, annual or perennial herbaceous vegetation at the hedge base, and often a ditch. These all vary in size between regions, and between farms within regions. The structure of hedges in Britain has also changed with time (Barr *et al.*, 1994; Westmacott & Worthington, 1997), and is known to influence the composition of bird communities on farmland (Green *et al.*, 1994; Parish *et al.*, 1994). This may explain, in part, why many farmland species have declined independently of reductions in hedge length (Gillings & Fuller, 1998), but little is known about the impact of changes in the overall field boundary structure on farmland passerines. Herbaceous vegetation in field boundaries is used as a nesting habitat by Whitethroats and Yellowhammers, and could also influence their breeding distribution. This habitat has been lost or greatly reduced on many arable farms as a consequence of spray and fertiliser misplacement and ploughing into the hedge base (Boatman, 1989), although it is maintained on some farms as nesting habitat for gamebirds (Rands, 1987; Boatman *et al.*, 1992).

Breeding density alone is not always a reliable indicator of habitat quality. Habitats supporting high breeding densities can be associated with low breeding success, and become population sinks if sustained by immigration rather than reproduction (Van Horne, 1983; Pulliam, 1988). This paper assesses both the presence of breeding territories, and the nesting success of Whitethroats and Yellowhammers in relation to field boundary habitats.

6.2 METHODS

6.2.1 Territory establishment

The influence of field boundary structure on the presence of breeding Whitethroats and Yellowhammers was studied in 1998 at Loddington (Leicestershire; 52.36N 0.50W), a 333ha mixed arable and livestock farm owned and managed by the Allerton Research and Educational Trust. The farm is influenced strongly by management for wild gamebirds (Boatman & Brockless, 1998). Sampling of field boundaries in the area surrounding Loddington was based on four compass bearings radiating from the centre of Loddington, each crossed at 1-km intervals by a series of 1-km transects (Figure 6.1). The first of the four bearings was selected at random. The remaining three bearings were then selected at 90° intervals from the first. Field boundary hedges crossed by the 1-km transects, and by similar transects within the farm, were used for the study. A total of 93 hedges, with fields on both sides were included, but hedges adjoining roads or farm tracks were ignored. Field boundaries lacking hedges were also excluded from the study. Each hedge was visited in May within three hours of dawn, and the presence or absence of territorial Whitethroats and Yellowhammers was recorded within a 100-m continuous length of hedge, crossed by the transect line.

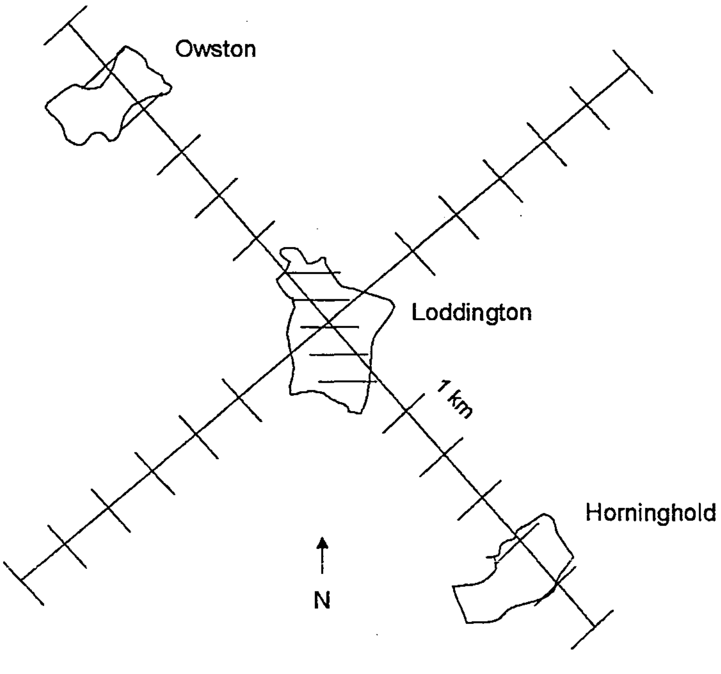

Figure 6.1. Relative positions of study sites and 1-km transects used to sample field boundaries within and outside Loddington (Leicestershire) in May, 1998.

The number of trees per 100-m was recorded. Field boundary structure was recorded on each side of hedges at points distributed at five 20-m intervals along the 100-m lengths. Hedge height and width, depth of ditch (where present) and herbaceous strip width (from hedge base to crop or bare ground) were measured using a calibrated stick at each point, and mean values calculated for each hedge. In addition, height of herbaceous vegetation was measured to the nearest 5-cm at each point. Mean herbaceous strip widths on each side of the hedge were added and log-transformed (log10(x+1)) to normalise the distribution of residuals. This produced a single figure for analysis of available habitat. A visual estimate (to the nearest 5%) of the proportion of grasses, umbellifers, cleavers *Galium aparine*, stinging nettle *Urtica dioica,* and bramble *Rubus fruticosus*, the most abundant plant taxa, was made within a 0.4-m quadrat at each point.

Forward stepwise logistic regression was used to investigate the relationship between field boundary characteristics and presence or absence of each bird species. Crops were classed as either arable or grass in order to test for effects of crop types adjacent to field boundaries. The data for boundaries of individual fields, including those referred to above, were also used to compare herbaceous vegetation height and herbaceous strip width between arable and grass fields.

6.2.2 Nest survival

Nest monitoring was conducted in each of the years 1995-1998. Nests of Whitethroat and Yellowhammer were located in May and June at Loddington, and at two additional sites (Horninghold and Owston) located along the random bearings, 5 km from Loddington (Figure 6.1). Nests were visited at 3-7 day intervals and the contents recorded. Predation was assumed to have occurred if the contents of the nest had been removed since the previous visit, or if clear signs such as broken egg shells or partially eaten young were visible. It was rarely possible to determine the identity of nest predators from signs left at the nest. Nest height above ground and the use of herbaceous or shrubby vegetation were recorded on the first visit, and nest concealment was recorded using a three-point subjective scale of 'well-hidden', 'part hidden', and 'exposed'. Meteorological data, comprising average daily temperature (mean of minimum and maximum) and daily rainfall, were provided by the Harold Martin Botanical Gardens located approximately 12km west of our study sites. In addition, breeding densities of Carrion Crows *Corvus corone* and Magpie *Pica pica* at each of the three sites were determined annually using nest counts.

To avoid possible bias associated with locating a disproportionately large number of successful nests, estimation of the daily probability of nest survival was based on the methods of Mayfield (Mayfield, 1975). We used an extension of this method (Aebischer, 1999) to relate nest survival rates to continuous and categorical variables. We modelled nest outcome as a binary variable (0=failure, 1=success) by logistic stepwise regression, incorporating observation period (the time between nest discovery and either success of failure) as the binomial denominator. Laying, incubation and nestling stages of the nesting period were treated separately. Where nests failed between visits, failure was assumed to have occurred half-way between the penultimate and final visit. Where eggs hatched, or nestlings fledged between visits, the half-way point between visits was again assumed, unless the resulting timespan fell outside the known incubation or nestling period for Yellowhammer (incubation: 12-14 days, nestling: 11-13 days (Cramp & Perrins, 1994) and Whitethroat (incubation: 9-14 days, nestling: 10-12 days, Cramp & Brooks, 1992). The change in residual deviance resulting from the removal of a variable from the model was used to test its significance against a χ^2 distribution with the appropriate degrees of freedom (Aebischer, 1999).

For each site, variables included month of observation, Carrion Crow and Magpie abundance, the three-point nest concealment score, nest height (log-transformed) and means (for the five-day period preceding success or failure) for rainfall (log-transformed) and temperature. For Yellowhammer, a two-level categorical habitat variable described nest location in hedge or herbaceous vegetation. Daily nest survival rates calculated for each nesting stage were combined to give overall nest survival rates (proportion of nests surviving to produce one or more young) for each site and year. These were arcsine transformed and compared between species using a paired t-test. Nest survival analysis was carried out using Genstat 3.2 (Payne *et al.*, 1997), and logistic regression using SPSS 7.

6.3 RESULTS

6.3.1 Territory establishment

The 1998 field boundary data revealed a significant relationship between Whitethroat and Yellowhammer presence and certain field boundary features. For both species there was a disproportionately high occurrence in hedges with wider herbaceous strips, with those of less than 1 m being totally devoid of Whitethroats (Figure 6.2). Whitethroats occupied 47%, and Yellowhammers 53% of field boundaries with strips exceeding 3 m in total width. Herbaceous strip width had a positive influence on the presence of both species and hedge height had a negative influence on the presence of whitethroats (Tables 6.1 & 6.2). Ditch depth had a strong positive influence on Yellowhammer occurrence. None of the plant taxa recorded were associated with presence of either species.

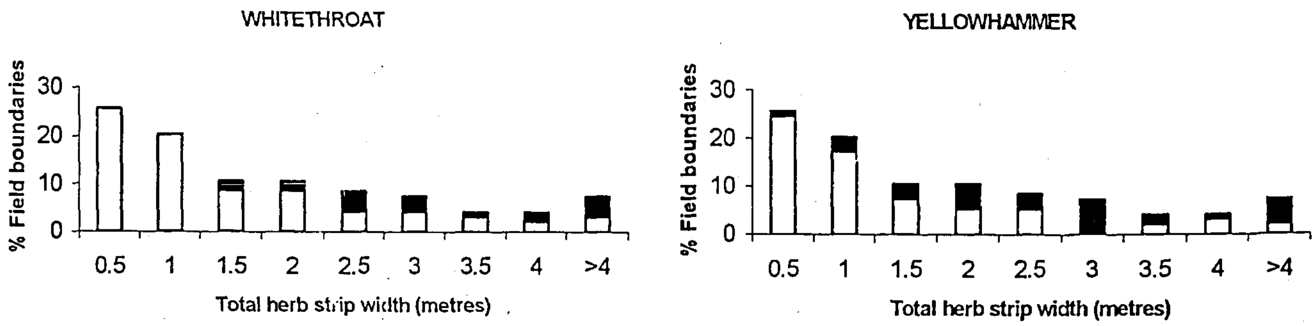

Figure 6.2. Frequency distribution of herbaceous strip widths showing proportions (shaded) adopted by breeding Whitethroats and Yellowhammers in Leicestershire. Widths are the sum of both sides of sampled hedges.

Table 6.1. Mean values (metres ± se) for field boundary characteristics associated with the presence of territorial whitethroats and yellowhammers.

	Hedge height	Herbaceous strip width	Ditch depth
Whitethroat	1.83 ± 0.12	3.17 ± 0.40	
No whitethroat	2.83 ± 0.16	1.23 ± 0.13	
Yellowhammer		2.63 ± 0.30	1.09 ± 0.12
No yellowhammer		1.12 ± 0.14	0.26 ± 0.06

Table 6.2. Partial regression coefficients for variables selected by logistic regression models. * = P<0.05, ** = P<0.01, *** = P<0.001.

	Hedge height	Herbaceous strip width	Ditch depth	χ^2
Whitethroat	-0.261**	0.368***		40.30 df=2
Yellowhammer		0.221**	0.294***	43.23 df=2

As the herbaceous component of field boundaries affected both species, herbaceous vegetation height and herbaceous strip width in arable and grass fields were compared. Both were significantly greater in arable fields than in grass (width, t_{161} = 5.69, .P<0.001; height, t_{161} = 6.86, P<0.001). However, there was no significant effect of crop type on Whitethroat or Yellowhammer presence, or interaction between crop type and herbaceous strip width.

6.3.3 Nest location

The nest data collected in the 1995-1998 period revealed further habitat associations. Of the 151 Whitethroat nests for which data were available, 95% were positioned in herbaceous vegetation in or away from the hedge base, rather than in the shrubby vegetation of the hedge (χ^2_1 =118.35, P<0.001), while for the 276 Yellowhammer nests, the proportion in herbaceous vegetation was 49% (χ^2_1 =0.45, ns). Yellowhammer nests in hedges were higher (mean 0.78 ± 0.05m) than in herbaceous vegetation (0.10 ± 0.05m, t_{232} = 14.05, P<0.001), but nest concealment scores did not differ between habitats (χ^2_2 = 1.09, ns). Within herbaceous vegetation, the height of nests found at laying or early incubation stages increased through the nesting season for both Yellowhammer (r_{221} = 0.249, P<0.001) and Whitethroat (r_{112} = 0.389, P<0.001).

6.3.4 Nest survival

Average daily survival rates (± se) for Whitethroats and yellowhammers at laying, incubation and nestling stages in 1995-1998 are given in table 6.3. For Whitethroats, the rate of nest survival at the nestling stage was positively associated with temperature (χ^2_1 =5.69, P<0.05). For Yellowhammers, temperature influenced positively the rate of nest survival during incubation (χ^2_1 =23.6, P<0.01) and nestling stages (χ^2_1 =14.6, P<0.01). Survival rates of Yellowhammer nests with nestlings were significantly lower for nests in hedges than for those in herbaceous vegetation (χ^2_1 = 4.60, P<0.05; figure 6.3). No other recorded variables influenced nest survival and there were no significant site or year effects at any nesting stage. Across the three sites and four years of the study, overall rate of nest survival was higher for Whitethroats than for Yellowhammers (t_{11} =3.93, P=0.002; Table 6.4).

Table 6.3. Whitethroat and yellowhammer daily nest survival rates (± se) for laying, incubation and nestling stages.

	Laying	Incubation	Nestling
Whitethroat	0.991 ± 0.072	0.982 ± 0.046	0.977 ± 0.005
Yellowhammer	0.976 ± 0.013	0.971 ± 0.004	0.970 ± 0.005

Table 6.4. Whitethroat and yellowhammer nest survival rates to fledging for the three study sites over the period 1995-1998.

	Whitethroat			Yellowhammer		
	Rate	se	Nests	Rate	se	Nests
1995						
Horninghold	55.6	2.04	13	31.5	6.8	19
Owston	82.6	1.16	8	24.9	16.34	26
Loddington	80.3	3.69	9	55.7	3.06	45
1996						
Horninghold	46.3	2.10	20	35.4	2.90	10
Owston	77.3	1.17	12	42.4	3.08	23
Loddington	75.9	1.05	19	53.3	1.20	57
1997						
Horninghold	39.1	2.37	8	18.8	9.46	16
Owston	71.5	1.54	14	13.5	9.05	5
Loddington	62.7	3.05	32	46.9	3.58	38
1998						
Horninghold	33.1	5.74	2	48.5	2.18	10
Owston	62.4	1.4	3	57.1	1.87	2
Loddington	76.4	1.4	11	62.9	1.22	25
Total			151			276
Mean	63.6	4.85		40.9	4.63	

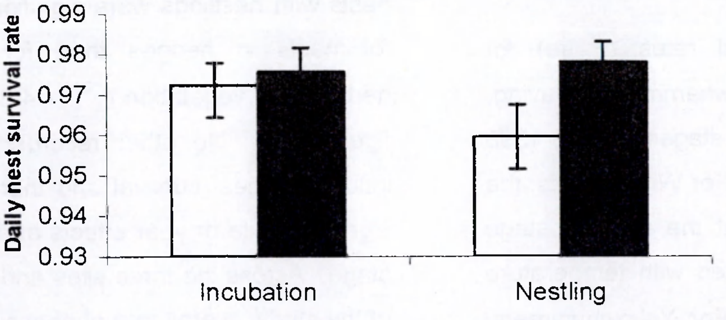

Figure 6.3. Yellowhammer nest survival rates (± se) at incubation and nestling stages in hedges (open bars) and herbaceous vegetation (shaded bars) in Leicestershire field boundaries.

6.4 DISCUSSION

Width of herbaceous strips in field boundaries influenced the occurrence of Whitethroats, while the occurrence of Yellowhammers was influenced more by the presence of vegetated ditches, supporting the findings of Kyrkos (1997). Biber (1993) reported an influence of herbaceous vegetation on Yellowhammer breeding habitat selection. Our study area has heavy clay soil and many ditches and it is possible that in areas with lighter more free-draining soil and fewer ditches, field boundary vegetation width has a greater influence on Yellowhammers.

Since a major population crash of Whitethroats occurred in 1969, coinciding with severe drought in the species' winter quarters (Baillie & Peach, 1992) their numbers have recovered less on farmland than in riparian habitats (Crick *et al*., 1997). The widespread loss of herbaceous vegetation from arable field boundaries in the intervening period (Boatman *et al*., 1992) could have limited the recovery of Whitethroats on arable farmland. However, in our study area, grass fields had significantly less herbaceous vegetation than arable fields, and intensive grazing by livestock could have equal or greater impact on both Whitethroats and Yellowhammers than the damage to herbaceous vegetation caused by current arable farming operations. This influence of livestock could contribute to the concentration of both species in the arable east of England (Gibbons *et al*., 1993). However, in the case of the more sedentary Yellowhammer, the presence of cereals is likely to have a direct effect on breeding density, for example by providing a source of food in both summer (Stoate *et al*., 1998), and winter (Kyrkos, 1998).

Whitethroats nested almost exclusively in herbaceous vegetation, rather than in hedges, and had higher nest survival than Yellowhammers, which nested in both habitats. Although Yellowhammer nests with eggs showed no significant difference in daily nest survival rates between habitats, nests with young had significantly higher survival rates in herbaceous vegetation sites than in hedges. Lower susceptibility to predation in herbaceous vegetation could be attributed to the structure of the habitat reducing visibility to predators (although our data suggest this was not the case), a different predator community in the two habitats, or to density dependent effects resulting from the larger number of passerine species nesting in hedges.

More than half of Whitethroat diet comprises moths and caterpillars (Moreby & Stoate, in press), many of which are associated with herbaceous plants, including perennial grasses and umbellifers, in field boundaries. Whereas Yellowhammers in our study area foraged at distances of up to 300m from nest sites (Stoate *et al.*, 1998), Whitethroats gathered most of their food within an estimated 30m of the nest, making the presence of invertebrate-rich habitat an important component of the breeding territory. For Whitethroats, misplaced herbicides and insecticides in field boundaries is likely to influence the abundance of this invertebrate food, as well as nesting habitat (Longley *et al.*, 1997; Haughton *et al.*, 1999). Temperature had a positive influence on nest survival of both species in this study. Activity and availability of invertebrate food are likely to be reduced at low temperatures, when there are competing needs to forage and brood nestlings.

Habitat management that permits the development of tall perennial herbaceous vegetation would benefit both Whitethroats and Yellowhammers. Although we have not distinguished between annual and perennial grasses in this study, the results suggest that the more pernicious components of field boundary vegetation such as cleavers had no positive influence the occurrence of either species. Development of suitable herbaceous field boundary habitat could therefore be an acceptable option for farmers, and the use of this habitat as gamebird nesting cover, and as wintering sites for beneficial invertebrates, provide additional incentive for its management.

The cost of establishing such habitat is not high (Chaney *et al.*, 1999), and in England, financial incentives to farmers to create herbaceous strips in field boundaries are available within an agri-environment scheme (the Countryside Stewardship Scheme). However, in practice, farmers sometimes cut such vegetation to permit access for walkers, riders or vehicles, thereby reducing the value of this habitat to breeding Whitethroats and Yellowhammers. Management of uncut perennial herbaceous field boundary strips has been shown to benefit whitethroats in Switzerland (Jenny *et* *al.*, 1997) and could benefit this and other farmland species if applied more widely in Britain.

6.5 ACKNOWLEDGEMENTS

Loddington estate is owned and managed by the Allerton Research and Educational Trust. The work was funded by the Ernest Cook Trust, the Habitat Research Trust and the Whitley Animal Protection Trust and the Game Conservancy Trust. Meteorological data were provided by the Harold Martin Botanical Gardens. Nicholas Aebischer provided statistical advice and commented on the manuscript which was also improved by Dan Chamberlain and Peter Vickery.

6.6 REFERENCES

Aebischer, N.J. (1999) Multi-way comparisons and generalised linear models of nest success: extensions of the Mayfield method. *Bird Study* **46** suppl.: 22-31.

Baillie, S.R. & Peach, W.J. (1992) Population limitation in Palaearctic-African migrant passerines. *Ibis* 134 supple. **1**: 120-132.

Barr C, Gillespie M & Howard D. (1994) *Hedgerow Survey 1993 – stock and change estimates of hedgerow length in England and Wales. 1990-1993.* Institute of Terrestrial Ecology, Grange-Over-Sands, Cumbria.

Biber O. (1993) [Availability and use of hedges and shrubs as nest sites by yellowhammers *Emberiza citrinella* in an area of intensive agriculture in Switzerland] *Der Ornithologische Beobachter* **90**: 115-132.

Stoate, C., Moreby, S.J. & Szczur, J. (1998) Breeding ecology of farmland yellowhammers *Emberiza citrinella. Bird Study* **45**: 109-121.

Boatman N D. (1989) Selective weed control in field margins. *Brighton Crop Protection Conference – Weeds* **2**: 785-794.

Boatman N D, Blake K A, Aebischer N J & Sotherton N W. (1992) Factors affecting the herbaceous flora of hedgerows on arable farms and its value as wildlife habitat. In: Watt, T.A. & Buckley, G.P. (eds.) *Hedgerow Management and Nature Conservation.* British Ecological Society, Conservation Ecology Group. 33-46.

Boatman, N.D. & Brockless, M.H. (1998) The Allerton Project: Farmland management for partridges (*Perdix perdix, Alectoris rufa*) and pheasants (*Phasianus colchicus*). *Gibier Faune Sauvage* **15**: 563-574.

Chaney, K., Wilcox, A., Perry, N.H. & Boatmen, N.D. (1999) The economics of establishing field margins and buffer zones of different widths in cereal fields. *Aspects of Applied Biology* **54**: 79-84.

Cramp, S. & Perrins, C.M. (1994) *Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of the Western*

Palearctic. Vol. IX Buntings and New World Warblers. Oxford University Press.

Cramp, S. & Brooks, D.J. (1992) *Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of the Western Palearctic. Vol. VI Warblers*. Oxford University Press.

Crick H Q P, Baillie S R, Balmer D E, Bashford RI, Dudley C, Glue DE, Gregory R D, Marchant J H, Peach, W J & Wilson A M. (1997) *Breeding Birds in the Wider Countryside: their conservation status (1971-1995)*. British Trust for Ornithology, Thetford.

Gibbons D W, Reid J B & Chapman R A. (1993) *The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991*. Poyser, London.

Gillings, S. & Fuller, R.J. (1998) Changes in bird populations on sample lowland English farms in relation to loss of hedgerows and other non-crop habitats. *Oecologia* **116**: 120-127.

Green R E, Osborne P E & Sears E J. (1994) The distribution of passerine birds in hedgerows during the breeding season in relation to characteristics of the hedgerow and adjacent farmland. *Journal of Applied Ecology* **31**: 677-692.

Haughton, A.J., Wilcox, A., Chaney, K. & Boatman, N.D. (1999) The effects of different rates of glyphosate on non-target invertebrates in field margins. *Aspects of Applied Biology* **54**: 185-190.

Jenny, M., Lugrin, B., Weibel, U., Regamey, J-L & Zbinden, N. (1997) *Der ökologische Ausgleich in intensiv genutzten Ackerbaugebieten der Champagne genevoise GE und des Klettgaus SH und seine Bedeutung für Vögel, Pflanzen und ausgewählte Wirbellose*. BUWAL.

Kyrkos A. (1997) Behavioural and demographic responses of yellowhammers to variation in agricultural practices. Unpublished PhD thesis. Oxford.

Longley, M., Cigli, T., Jepson, P.C. & Sotherton, N.W. (1997) Measurements of pesticide spray drift deposition into field boundaries and hedgerows. 1. Summer applications. *Environ. Txicol. Contam.* **16**: 165-172.

Mayfield, H. (1975) Suggestions for calculating nest success. *Wilson Bull.* **87**: 456-466.

Moreby, S.J. & Stoate, C. (in press) A quantitative comparison of neck collar and faecal analysis to determine passerine nestling diet. *Bird Study* **45**: 109-121.

Payne, R.W., Lane, P.W., Ainsley, A.E., Bicjknell, K.E. Digby, S.A., Harding, S.A., Leech, P.K., Simpson, H.R., Todd, A.D, Verrier, P.J. & White, R.P. (1987) *Genstat 5 Reference Manual*. Clarendon Press, London.

Parish T, Lakhani K H & Sparks T H. (1995) Modelling the relationship between bird population variables and hedgerow and other field margin attributes. II. Abundance of individual species and of groups of similar species. *Journal of Applied Ecology* **32**: 362-371.

Rands M R W. (1987) Hedgerow management for the conservation of partridges *Perdix perdix* and *Alectoris rufa*. *Biological Conservation* **40**: 127-139.

Pulliam, H.R. (1988) Sources, sinks and population regulation. *Am. Nat.* **132**: 652-661.

Van Horne, B. (1983) Density as a misleading indicator of habitat quality. *J. Wildl. Manage.* 47: 893-901.

Westmacott R & Worthington T. (1997) *Agricultural Landscapes: A Third Look.* Countryside Commission, Walgrave.

6.7 Appendix:

Nest predation in field boundaries: an experimental comparison of hedge and herbaceous vegetation

The results presented in chapter 6 reveal a significant difference in nest predation rates between yellowhammer nests at the nestling stage in hedges and those in herbaceous vegetation at the hedge base. This was tested experimentally in June 1998 at a site 1km from Loddington where there was no control of potential nest predators.

Methods

Sixty yellowhammer nests (collected the previous year after they had fledged young or failed) were positioned in field boundaries in pairs, with one nest in the hedge and another in the herbaceous vegetation approximately 2m away. Nests in hedges were placed at a mean height of 1.5 ± 0.04m and nests in herbaceous vegetation were placed within 0.1m of the ground. All nests were concealed from view from outside the vegetation in which they were placed. Pairs of nests were separated by a distance of approximately 60m.

Each nest was fitted with two artificial eggs (made of white FIMO® modelling compound) and one fresh budgerigar (*Melopsittacus undulatus*) egg. Artificial eggs were sewn into the nest base so that they would not be removed by predators. Nests were then visited each day for a period of ten days in order to record the contents. Wherever possible, nest predators were identified from the imprints left in artificial eggs.

Results

Nests in hedges survived 8.67 ± 0.46 days (mean ± se), while those in herbaceous vegetation survived 9.57 ± 0.44 days. These periods were not statistically different (t_{29} =0.268, P=0.79). However, imprints left in the artificial eggs suggested that the predators in the two habitats were different. Of the six nests depredated in herbaceous vegetation, four were taken by badgers, while six of the eight nests depredated in hedges were taken by corvids.

Discussion

Although there was no difference between the survival of nests in hedges and that of nests in herbaceous vegetation in this experiment, this is consistent with the results from real nests where there was also no difference at the egg stage. Nest predation may be higher at the nestling stage because of greater adult activity, or greater calling activity of the nestlings themselves.

Artificial nests experiments should, in any case, be interpreted with some caution as they represent more closely real nests that have been deserted than nests that are being incubated. Eggs in the latter are likely to be better concealed (by the incubating bird) and may be defended by the adults if approached by a predator.

In spite of this, the use of the two habitats by different predators is relevant. This result suggests that the effect of habitat on nest predation rates will depend on the predator communities present at each site. Sites where herbaceous vegetation is not available, and nests are located in hedges will be susceptible to high predation rates where corvids are abundant but may exhibit high survival rates if corvid numbers are low. Similarly, nests in herbaceous vegetation may exhibit higher rates of predation than those in hedges if badger numbers are high, relative to the abundance of corvids.

This may explain the difference in the influence of hedge and herbaceous habitats between the Loddington study and that conducted at Wytham (Kyrkos, 1997) where yellowhammer nest survival was higher in hedges than in herbaceous vegetation. Although speculative, this highlights the need to consider interactions between habitat effects and predator abundance, and the variability of predator communities between sites.

Chapter 7

Cultural ecology of Whitethroat (*Sylvia communis*) breeding habitat management by farmers: field boundary vegetation in lowland England

7.1 Introduction

This chapter investigates the use of field boundary habitat by a migratory farmland bird species, the whitethroat (*Sylvia communis*), and the decisions taken by farmers for the management of that habitat. This species is strongly associated with farmland in both its breeding and wintering areas and chapter 8 takes a similar approach to habitat management in the whitethroat's sub-Saharan wintering area.

The findings presented in this chapter have wider implications for other farmland birds, especially those, such as grey partridge (*Perdix perdix*) (Rands, 1986) and yellowhammer (*Emberiza citrinella*) (Chapter 6; Bradbury & Stoate, 2000), which use herbaceous field boundary vegetation as a nesting habitat. This vegetation is also an important habitat for a wide range of other vertebrate and invertebrate species. Perennial grasses form a permanent sward in which annual grasses and other weeds cannot compete (Boatman, 1989). Establishment of such swards in field boundaries therefore has the potential to minimise weed establishment in field boundaries and their egress into neighbouring

crops. Other potential benefits include the use of this habitat by nesting gamebirds, and by beneficial predatory invertebrates (Thomas *et al.*, 1991). Perennial grasses in field boundaries provide over-wintering habitat for Carabidae and Staphylinidae which control invertebrate pests of arable crops in spring, and this biological pest control provides an additional or alternative incentive for the management of field boundary vegetation (Wratten, 1988). The habitat is also used by other beneficial invertebrate predators such as hoverflies (Cowgill *et al.*, 1993) and spiders (Kromp & Steinberger, 1992).
The creation of herbaceous field boundary strips is currently supported by the Countryside Stewardship Scheme under EU Regulation 1257/99. The inclusion of this habitat as one of the first for which a costed action plan was published highlights its importance for biodiversity (Anon, 1995; Smallshire & Cooke, 1999). This study of farmer attitudes is therefore relevant to this and similar agri-environment schemes in Britain.

Breeding abundance of many farmland bird species is influenced by hedgerow density and structure (Arnold, 1983; MacDonald & Johnson, 1995; Parish *et al.*, 1995) and invertebrate abundance and diversity are also higher in large, structurally diverse hedges (Maudsley, 2000). Whitethroat abundance is closely correlated with hedgerow density (O'Connor, 1984), and the availability of this habitat is likely to influence changes in breeding abundance of this species. Recent increases in breeding abundance in riparian habitats have been greater than those on farmland where whitethroat densities were formerly higher than at present (Crick *et al.*, 1997). Barr *et al.* (1994) reported a 1.7% annual rate of hedgerow loss in the 1984-1990 period, but this had reduced to 0.8% pa in the 1990-1993 period when the rate of hedge planting had increased from 0.4% pa to 1.0% pa. In the regions studied by Westmacott and Worthington (1997) 16,280 km of hedges were removed in the 1983-1994 period, compared with 3,225 km planted. Hedge removal had been greater in the period up to 1983.

In addition to the complete removal of field boundaries in order to improve short-term economic efficiency, or their neglect following loss of livestock from arable farms (Barr *et al.*, 1993; Westmacott and Worthington, 1997), farmers have a considerable influence on the suitability of remaining habitat for whitethroats, through their management of crops. Deposition of fertiliser into perennial vegetation at the field edge has contributed to a change in botanical composition towards annual weeds (Rew *et al.*, 1992; Boatman *et al.*, 1994). The field margin flora is now often dominated by competitive species, characteristic of high soil fertility and often associated with disturbance, include *Urtica dioica*, *Bromus sterilis* & *Galium aparine* (Boatman *et al.*, 1992). Such changes encourage the perception among farmers that field boundaries are a source of weeds, leading to the further destruction of this habitat through deliberate or accidental use of herbicides, ploughing into the field edge, and in many cases complete removal (Boatman, 1989). In the late 1980s around 60% of farmers were recorded using herbicides in their field boundaries (Boatman, 1989; Marshall & Smith, 1987).

Spray drift from crops into field boundaries can be considerable, but is also very variable and influenced by wind speed, crop height and spray equipment (Cuthbertson & Jepson, 1988). Reducing pesticide use in field headlands can minimise drift into field boundaries, and the diversity of adjacent vegetation can increase as a result (Snoo & Poll, 1999). Such selective use of pesticides in field headlands was originally developed as a means of increasing abundance of arable invertebrates as food for gamebird chicks (Sotherton, 1991).

Chapter 6 has shown that the presence of whitethroats in Leicestershire field boundaries is strongly influenced by hedge height and herbaceous strip width. This study explores this relationship in a second region, Wiltshire, where predominantly chalk soils are associated with fewer ditches in field boundaries, with implications for the structure and width of field boundary vegetation. The suitability for whitethroats of both hedges and field boundary herbaceous vegetation is determined by farmers' management of crop as well as non-crop areas. In turn, such management is likely to be determined by farmers' attitudes to their crop management, their supplementary interests in other uses for the same land, and the people influencing their management decisions (MacDonald & Johnson, 2000). There is therefore a need to improve our understanding of these influences and interests if field boundary habitats are to be improved for breeding whitethroats and many other farmland species.

7.1.1 Farmers' attitudes

The introduction of economic incentives for conservation management on farmland has also increased awareness of some environmental issues, and many management practices, including those involving field boundary vegetation, have been widely adopted under the

Countryside Stewardship Scheme, and more locally, under a pilot Arable Stewardship Scheme. However, such management does not necessarily result in the intended conservation benefits where farmers' interests in its implementation are purely economic. Grass strips planted along field boundaries in England under the Countryside Stewardship Scheme have considerable potential for increasing the area of suitable habitat for whitethroats and other field boundary-nesting species. However, these are sometimes mown, removing any potential for their use by whitethroats (although they may still represent important foraging habitats for some other species), and may even be used by farm vehicles so that the vegetation structure required for nesting and foraging by whitethroats is destroyed.

Farmers' attitudes to field boundary management can be influenced by their interests in alternative uses for this habitat which do not necessarily have economic benefits for the farm business. Historically, such interests have included fox hunting which has been a major influence on hedgerow structure, with hedges in hunting areas being relatively low and intensively managed. Herbaceous vegetation in field boundaries is used as nesting habitat by gamebirds, thereby providing incentive for the management of these habitats by those with shooting interests (Rands, 1986; Boatman *et al*, 1992).

Farmers' knowledge of, and interest in, such aspects of field boundary ecology and use are likely to have considerable influence on their management of both the habitat itself, and of adjacent arable crops. This is likely to be influenced by the knowledge and interests of the other people with whom they associate, including family and advisors. In this study, a questionnaire survey of the farmers whose farms were visited to determine whitethroat habitat use was used to explore the interests of those farmers and the influences on them.

7.2. Methods

The study was conducted in southern Wiltshire and north-east Dorset on predominantly arable farms with underlying geology of chalk. The area is mainly arable, although many farms also have livestock. Pheasant shooting and fox hunting are commonly practised. Forty-nine farmers were initially contacted by letter in 1998, followed by a phone call in which they were asked for permission to visit the farm, and whether they would be prepared to complete a questionnaire on field boundary management at a later date. At each farm, field boundaries crossed by 1-km OS gridlines within the farm were visited in July 1998 and 1999 in order to record habitat attributes within a 100-m length of field boundary crossed by gridlines. Field boundaries were continuous, without hedge intersections or other habitat features and were at least 100-m apart.

For the assessment of habitat use by whitethroats, hedges with arable fields on each side (i.e. not roadside hedges) were taken as the sample unit. The presence or absence of whitethroats was first recorded along the 100-m length. Hedge height and width and herbaceous strip width were then measured (to the nearest 0.2-m) at five 20-m intervals along this length. Mean widths of herbaceous vegetation on both sides of the hedge were added and log-transformed ($\log_{10}(x+1)$) to normalise the distribution of residuals, producing a single figure for habitat availability. Visual estimates of the proportion of ground covered by grasses, umbellifers, cleavers *Galium aparine*, stinging nettle *Urtica dioica*, and bramble *Rubus fruticosus* were also made (to the nearest 10%) within a 0.4 x 0.4m quadrat, randomly selected at each point and averaged across the 100-m lengths. Logistic regression was used to investigate the relationship between whitethroat presence/absence and hedge height and width of herbaceous vegetation. Farm and year effects were tested as categorical variables. For assessment of field boundary habitat management by farmers, individual field boundaries were taken as sample units.

A questionnaire survey was used to examine farmer attitudes to their farming operations, and specifically their motivation for the management of field boundary habitats, and the influences on their management decisions (Table 7.1.). The questionnaire was sent to each of the 49 farmers after their farms had been visited for bird surveys and habitat assessments. Phone calls were made to those farmers not returning questionnaires, and shorter versions were sent to those who claimed to be unable to complete the whole questionnaire through lack of time. Forty-three completed the full version of the questionnaire, and a further four completed the shorter version. Two farmers failed to return either the original or the short version.

Principal components analysis was used to reduce the specific interests claimed by respondents to broad interest categories ('Cultural capital', 'Progressiveness' and 'Game and landscape'). Because of the use of ordinal scoring in the questionnaire, nonparametric tests were used to explore the relationship between interest categories and reported or observed behaviour in terms of crop and field boundary management. Farms were used as sample units. Hedge heights and herbaceous strip widths preferred by farmers were compared with farmers' actual behaviour in terms of hedge height and herbaceous strip width on their own farms. The influences on farmers' management decisions were also identified, and their impact on farmers' management was explored. Subjective norm values were calculated as the product of perceived influence and the direction of that influence (Carr & Tait, 1991).

Table 7.1. Questionnaire questions and multiple choice answers used in the study

Question	Answer
What type of fertiliser applicator do you use?	Oscillating spout / Spinner / Pneumatic / Liquid / Other
If you use applicators other than pneumatic or liquid, do you take action to reduce fertiliser application in field boundaries?	Yes / no
If 'yes' what action do you take?	Deflector plates / border disc / reduced revs. / tilting spreader
Do you use spring/summer insecticide applications on cereals as routine prevention or insurance (according to calendar) or only when threshold levels of insects are reached?	Prevention / threshold
Do you incorporate an aphicide with fungicide applications?	Yes / no / sometimes
Do you take any action to reduce spray drift into field boundaries?	Yes / no
If 'yes' do you use ...?	Twin fluid sprayer / sleeve boom / low drift nozzles / anti-drift additives / other
Do you reduce pesticide use on field headlands in spring and summer when applying ...?	Herbicides: yes / no Insecticides: yes / no
If you have sterile strips in your field boundaries, how do you keep them weed-free?	No sterile strips / herbicides / cultivation
What is your preferred width of herbaceous vegetation in field boundaries for each field?	Metres: 0 / 0.5 / 1 / 1.5 / 2 / >2
Do you apply herbicides directly to herbaceous vegetation in field boundaries?	Yes / no
How often do you cut your herbaceous vegetation in field boundaries?	>once per year / every year / every other year / every 3+ years / not at all
What is your preferred hedge height?	Metres: <1 / 1 / 1.5 / 2 / 2.5 / 3 / >3
How frequently do you cut your hedges?	Every year / every other year / different sides in alternate years / every 3+ years / not at all
What time of year do you trim your hedges?	Nov-Feb / Mar-Apr / May-Jul / Aug-Oct
Of the hedges present on your farm in 1970, please estimate the proportion removed since then	0% / 10% / 20% / 30% / 40% / 50%
Please estimate the proportion of hedges on your farm that has been planted since 1970	0% / 10% / 20% / 30% / 40% / 50%
How important are the following aspects of the farm to you as a farmer?	Generating income / investing capital / family heritage / enjoying countryside / walking or riding / hunting / rural social life / providing employment / bird watching / wildlife conservation / organic farming / integrated crop management / reared game management / wild game management / latest farming methods / latest equipment / livestock / landscape improvement (6 point score: not important-very important)
How important are the following in influencing your decisions regarding management of commercial crops?	Relatives / independent advisor / agrochemical company advisor / game or wildlife advisor / magazines / gamekeeper / neighbouring farmers / other local residents (6 point score: no influence-major influence)
How important are the following in influencing your decisions regarding management of hedges?	As above

How important are the following in influencing your decisions regarding management of herbaceous vegetation?	As above
Please indicate whether each of the following would agree or disagree with your decision to keep field boundaries clear of herbaceous vegetation	As above 6 point score: agree-disagree
Please indicate whether each of the following would agree or disagree with your decision to maintain hedge height at less than 1.5 metres	As above 6 point score: agree-disagree
Do you agree or disagree with the statement that herbaceous vegetation in field boundaries is a ...?	Source of weeds / site for wild flowers / source of insect pests / source of beneficial insects / place for songbirds / source of crop diseases / useful for gamebirds. 6 point score: agree-disagree
To what extent does the presence of the following influence your decisions regarding management of herbaceous vegetation?	Weeds / wild flowers / insect pests / beneficial insects / songbirds / crop diseases / gamebirds. 6 point score: not at all-considerably
Do you agree or disagree with the statement that the following are a desirable component of field boundaries on your farm?	Perennial grasses (e.g. cocksfoot, Yorkshire Fog) / annual grasses (e.g. sterile brome, blackgrass) / cleavers / umbellifers / stinging nettles / bramble
Farmers with shooting interests only	
Does the farm employ a gamekeeper?	Yes / no
How important are the following as priorities for the shoot on your farm?	Generate income / maintain tradition / entertain friends / entertain family / test shooting skills / enjoy countryside / other. 6 point score: Not important-very important

7.3. Results

7.3.1 Habitat use by whitethroats

Whitethroat presence in field boundaries was associated positively with the width of herbaceous vegetation (R= 0.292, P= 0.009, n= 70), and negatively with hedge height (R= -0.277, P= 0.011, n=70) (Table 7.2). These results are consistent with those previously obtained in a different farmland landscape with clay soils in Leicestershire (Chapter 6). There was no effect of farm or year.

Table 7.2. Mean hedge heights and herbaceous strip widths (metres ± se) in relation to territorial whitethroat presence or absence in Wiltshire. Herbaceous strip width relates to both sides of a hedge.

	Hedge height	Herbaceous strip width
Whitethroat	1.94 ± 0.19	1.96 ± 0.31
No whitethroat	2.67 ± 0.15	1.37 ± 0.10

7.3.2 Questionnaire results

7.3.2.1 Habitat structure

Farmers' preferred hedge height and mean actual hedge height were correlated ($r = 0.33$, $P<0.05$, $n = 45$), but actual hedge height (mean: 2.38 ± 0.09m) was greater than preferred height (2.06 ± 0.09m) ($t_{44} = 2.91$, $P = 0.006$) (Figure 7.1). Hedges on farm boundaries (mean ± se, 2.89 ± 0.19m) were significantly taller than road- and track-side hedges (2.13 ± 0.08m) ($t_{65} = 3.07$, $P=0.003$), with other internal farm hedges being of intermediate height (2.53 ± 0.12m).

Herbaceous strip width identified by farmers as being preferred on their farms (mean + se, 0.74 ± 0.05m) did not differ from the actual observed strip width (mean + se, 0.69 ± 0.09m) ($t_{45} = 0.02$, ns.) but these values were not correlated (Figure 7.2). Sixty-five percent of farmers preferred strip widths of 0.5m or less.

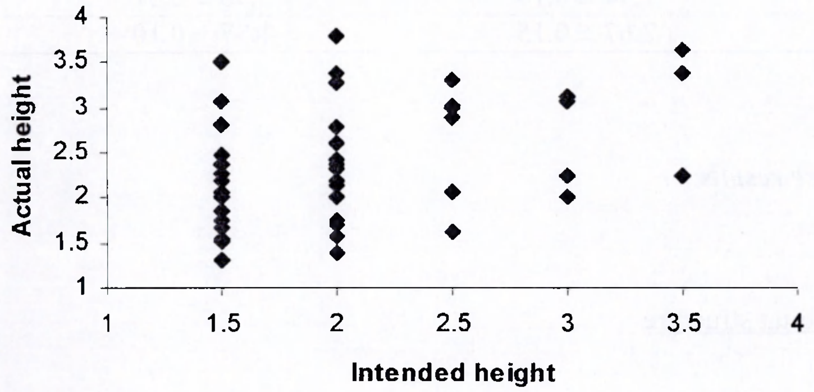

Figure 7.1. Plot of intended against actual hedge height (metres).

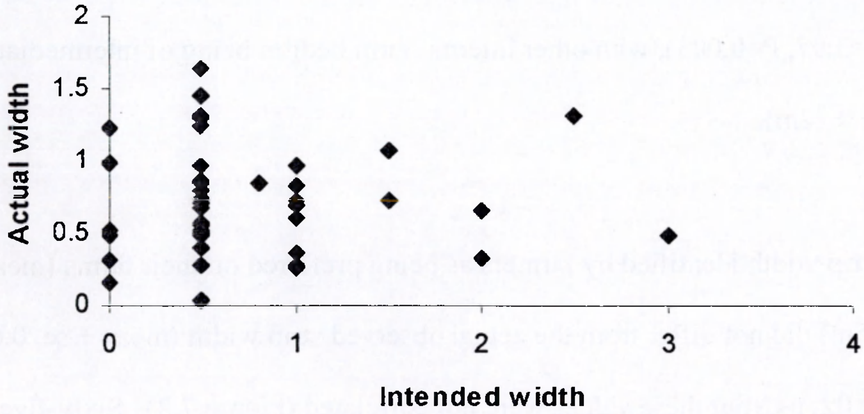

Figure 7.2. Plot of intended against actual herb strip width (metres).

7.3.2.2 Habitat components

Weeds were more important influences (higher scores) on the management of herbaceous vegetation than most other factors. Wilcoxon Z values, calculated for pairwise comparisons between weeds and other factors were: flowering plants, $Z = -2.84$ ($P=0.004$, $n= 45$), pests, $Z=-4.29$ ($P<0.001$, $n= 44$), gamebirds, $Z=-2.39$ ($P=0.017$, $n= 44$), disease, $Z=-4.58$ ($P<0.001$, $n= 44$), songbirds, $Z=-3.36$ ($P=0.001$, $n= 45$) and beneficial invertebrates, $Z=-3.65$ ($P<0.001$, $n= 45$). Perennial grasses were a significantly more desirable component of the field boundary flora than all other plant groups (all at $P<0.01$), and annual grasses and cleavers were significantly less desirable components of the field boundary flora than the other plant groups (all at $P<0.01$).

7.3.2.3 External inputs

Management practices were divided into positive and negative behaviours in terms of habitat management for whitethroats (Figure 7.3). Ninety one percent of farmers claimed to use fertiliser distributor equipment designed to minimise misplacement of nutrients in field boundaries and other non-crop habitats such as watercourses (positive behaviour), while 9% claimed to use oscillating spout distributors, or unmodified spinners (negative behaviour). Twenty five percent of farmers applied herbicides directly to field boundary vegetation (negative). Ninety five percent of farmers claimed to use insecticides only when pest thresholds in crops were exceeded (positive), and 66% claimed to take some steps to minimise spray drift (positive). Some farmers reduced the use of insecticides (24%) and herbicides (9%) in field headlands (positive).

7.3.2.4 Farmer interests

Generating income was the most important aspect of farming for 92% of the farmers, ranking significantly higher than any of the other categories (Wilcoxon, P<0.001, n=47) (Figure 7.4). However, two long-term interests, 'enjoying the countryside' and 'investing capital', equalled 'generating income' in importance for 38% and 26% of farmers respectively. Forty percent also listed 'livestock' as being of equal importance to these.

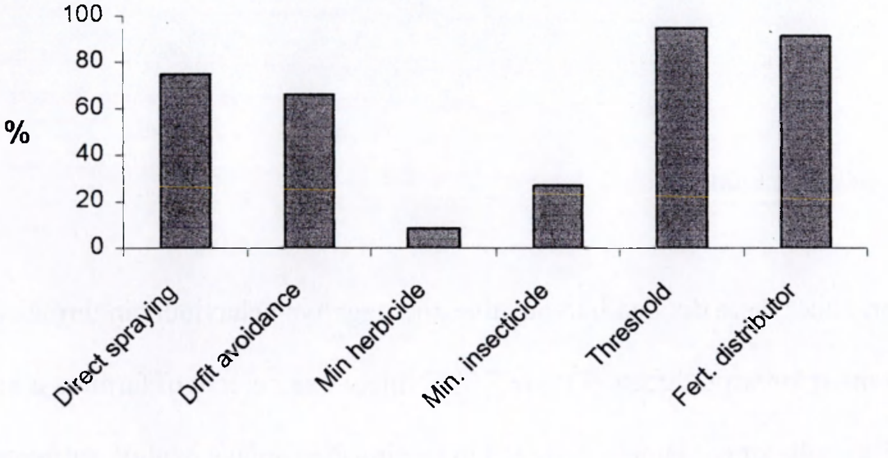

Figure 7.3. Proportion of farmers adopting management practices that are desirable in terms of their consequences for whitethroat ecology.

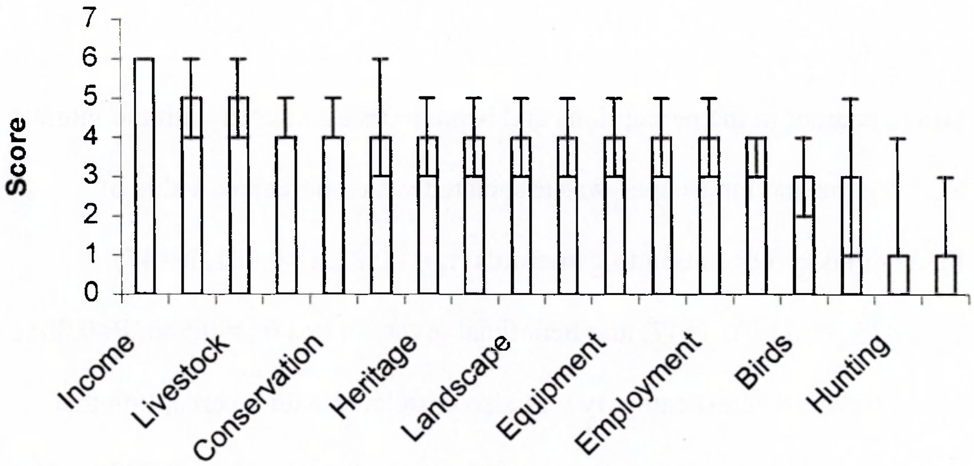

Figure 7.4. Median and inter-quartile ranges for farmer interests. The score represents a six-point scale from 1 (no interest) to 6 (considerable interest).

The first three interest categories identified by principal components analysis (Manly, 1994) were "cultural capital", "progressiveness" and "game and landscape". The individual components of each of the three categories derived from principal components analysis are listed in Table 7.3. Overall scores for each of the three broad interest categories were calculated as the sum of the component interests. The overall score for game and landscape was correlated with farm size ($r_s = 0.407$, $P=0.007$, $n= 43$). Sixty two percent of farmers had shooting interests and within these, economic incentives for game management ("generating income") scored lower than "entertaining friends" ($Z=4.10$, $P<0.001$, $n= 29$) and "enjoying the countryside" ($Z=4.252$, $P<0.001$, $n= 29$).

7.3.2.5 Influences on management: interests

Differences were apparent in the perceptions and behaviours associated with the interest categories. PC3 "Game and landscape" was associated with a perceived value of herbaceous field boundary vegetation to gamebirds (r_s = 0.582, P<0.001, n= 47), songbirds (r_s = 0.435, P<0.003, n=47) and beneficial invertebrates (r_s = 0.566, P<0.001, n=47). The score for this interest category was also correlated with a perception that brambles (r_s = 0.389, P<0.008, n=46) and perennial grasses (r_s = 0.306, P<0.039, n=46) were desirable components of field boundaries. Farmers in this group were influenced in their field boundary management decisions by gamebirds (r_s = 0.582, P<0.001, n=43), beneficial invertebrates (r_s = 0.566, P<0.001, n=43) and songbirds (r_s = 0.435, P<0.003, n=43).

Table 7.3. Interest categories and their components identified by principal components analysis

Interest categories	Eigen value	% variation	Component variables	Component loadings
PC 1 Cultural capital	3.951	20.0	Rural social life Enjoying countryside Investing capital Walking or riding	0.830 0.792 0.681 0.675
PC 2 Progressiveness	2.626	14.6	Latest equipment Latest methods Integrated crop management	0.831 0.720 0.621
PC 3 Game and landscape	2.307	12.8	Wild game management Reared game management Landscape improvement	0.843 0.812 0.642

The scores for the three interest categories derived from principal components analysis did not differ between positive and negative behaviours (fertiliser distributors, spray drift prevention, direct spraying of field boundary vegetation, pesticide use in headlands, and cutting frequency of hedges and herbaceous vegetation). However, for the individual interest variable "wildlife conservation", differences in behaviour were found between farmers with high and low scores. Those with high wildlife conservation interest scores (4-6) made more attempt to reduce fertiliser misplacement (χ^2_1 =12.29, P=0.004), reduce insecticide use in field headlands (χ^2_1 = 4.23, P=0.043), and avoid direct use of herbicides in field boundaries (χ^2_1 =7.94, P=0.010) than those with low conservation interest scores (1-3). No such differences were apparent for the other interests.

Farmers with high scores (4-6) for PC1 "cultural capital" and PC3 "game and landscape" did not differ from those with low scores (1-3) in their attitudes to botanical components of field boundary vegetation (Figure 7.5). However, attitudes towards plants differed between farmers with high and low "wildlife conservation" interests, with those with high interest being more tolerant of bramble (Mann Whitney U =90, P=0.015, n=46), nettle (U = 85, P=0.01, n=46) and umbellifers (U =86, P=0.014, n=46). There were no differences for perennial or annual grasses or cleavers.

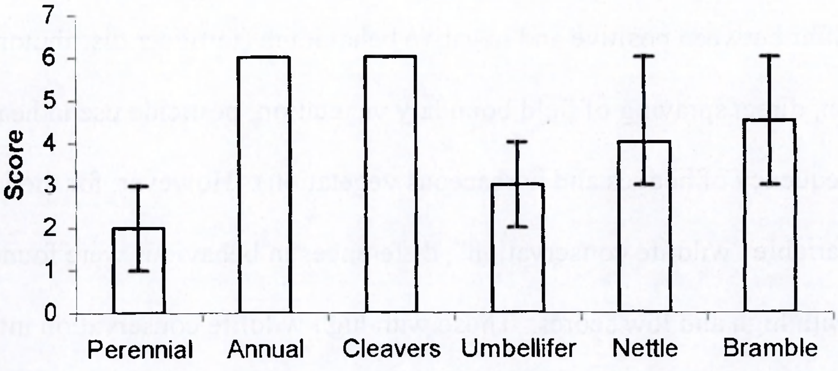

Figure 7.5. Median scores and inter-quartile ranges for farmers' attitudes to components of field boundary flora (1=desirable component, 6=undesirable component)

7.3.2.6 Influences on management: people and publicity

"Agrochemical company advisors" and "independent advisors" had significantly more influence on farmers' management decisions relating to their crops than all other potential influences (Wilcoxon, all at $P<0.001$, except "magazines" at $P<0.05$, $n=43$) (Figure 7.6). Magazines had greater influence than other potential influences where hedge management was concerned, although this influence was not significantly higher than that of "game and wildlife advisors", "gamekeepers", and immediate family. Magazines were also the greatest influence on management of field boundary vegetation, although their influence did not differ significantly from that of advisors or immediate family. Agrochemical company advisors and independent advisors had greater influence on farmers' management decisions relating to crops than to hedges and field boundary vegetation (P<0.001). The influence of magazines was also greater for management decisions regarding crops than for hedges (P<0.001) and field boundary vegetation (P<0.01), but they were equally influential for these non-crop habitats.

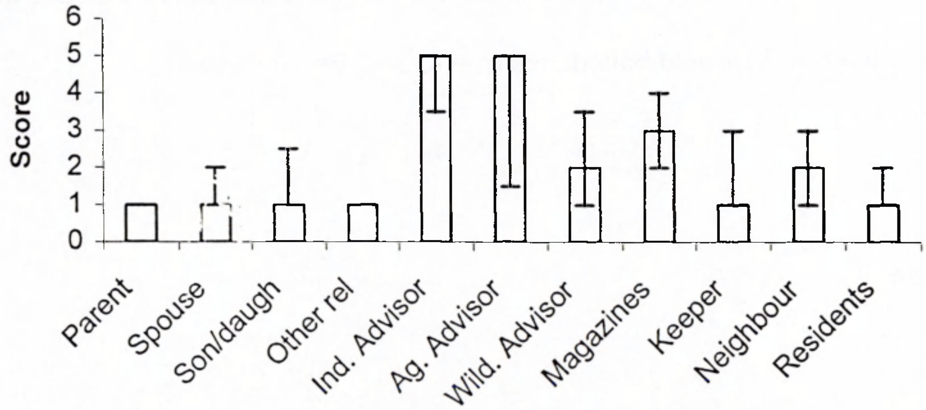

Figure 7.6. Median scores and inter-quartile ranges for influences on farmers' management decisions involving commercial crops (1 = low influence, 6 = high influence).

Farmers who claimed to be influenced by magazines were associated with reduced hedge cutting frequency (Mann Whitney U = 142.5, P=0.041, n=43), as were farmers who claimed to be influenced by local residents (U = 139, P=0.022, n=43). Farmers who were most influenced by independent advisors were more likely to spray field boundary vegetation (U = 122, P=0.035, n=43). Influence from agrochemical company advisors was negatively correlated with actual herb strip width (r_s = -0.345, P=0.02, n=43), but there was no relationship with spraying of field boundary vegetation. Subjective Norm values revealed a negative correlation between the influence of agrochemical company advisors and intended and actual hedge height (respectively, r_s = -0.344, P<0.05, n=38; r_s = -0.352, P<0.05, n=39). No such relationships were apparent for other potential influences, or for herb strip width. However, farmers whose field boundary management decisions were influenced by their attitudes towards weeds were associated with a lower proportion of grasses in their field boundaries (r_s = -0.394, P=0.007, n=45).

7.4. Discussion

7.4.1 Hedge management

Comparison of actual and intended hedge heights reveals a significant correlation between the two, but actual hedges are consistently higher, probably because farmers considered only internal hedges in responding to the questionnaire, whereas both internal and boundary hedges were included in the field assessment and boundary hedges are higher. Agrochemical company advisors and independent advisors appear to encourage farmers to maintain low hedges which would benefit whitethroats and possibly other species using relatively open habitats such as corn bunting, grey partridge, lapwing and skylark.

High hedges are generally associated with high bird species diversity and abundance of species such as robin (*Erythacus rubecula*), song thrush (*T. philomelos*) and chaffinch (*Fringilla coelebs*) (Green *et al.*, 1994) and considered preferable in conservation terms (Andrews & Rebane, 1994), but conservation interests of farmers in this study showed no relationship with hedge height. As bird species vary in their use of hedges of different heights, farms with a diversity of hedge heights are likely to support the greatest number of species. Farmers' decisions to reduce their hedge cutting frequency are influenced by reading magazines and the wishes of local non-farming residents. The impact of this practice on whitethroats is not known, although it could be beneficial if hedge height remains low and does not result in encroachment into adjacent herbaceous strips. Cutting hedges every two or more years is known to have conservation benefits for other bird and mammal species which feed on the fruit of hedgerow shrubs (Sparks & Robinson, 1999; Poulton, 1994). The impact of cutting frequency on invertebrates is poorly understood (Maudsley, 2000).

7.4.2 Herbaceous strip management

Actual herbaceous strip widths were similar to those intended by farmers, but some farmers claimed to have wider strips than was the case, and intended and actual widths were therefore not correlated. Herbaceous strip widths were strongly skewed towards narrow strips, creating unfavourable habitat for species such as whitethroat which are dependent on wide strips of herbaceous vegetation.

There was broad agreement amongst respondents that perennial grasses were desirable and that annual grasses and cleavers were undesirable, but 25% of farmers still applied herbicide directly to field boundary vegetation, destroying both perennial and annual plants. The proportion of farmers adopting more positive behaviours such as reducing fertiliser and pesticide misplacement in field boundaries was high, but this was not reflected in the reduction of pesticide use within commercial crops. Avoiding misplacement of arable inputs could be regarded by farmers as good agricultural practice, while reducing inputs overall is less likely to be perceived as such.

7.4.3 Farmer interests

Although generating income was the major interest for farmers, the expression of other high-ranking interests such as "enjoying the countryside" and "wildlife conservation" reflect a wider interest in the farming environment. This is apparent in the broad interest categories which indicate a range of worldviews amongst farmers. There are potential conflicts between long-term and short-term values, for example between the "cultural capital" approach and the desire to adopt the latest farming methods, expressed as "progressiveness" and widely considered to be detrimental to the farmland ecosystem (Nassauer & Westmacott, 1987; Stoate, 1996). Oreszczyn & Lane (1999) distinguished between the personal and professional attitudes of farmers towards hedges on their farms.

It has been argued that "progressiveness" amongst farmers may reduce the value of farmland as a habitat, but frees unproductive land which can be managed for non-agricultural uses such as wildlife conservation (Avery, 1995). However, this overlooks the fact that in the U.K. and across much of Europe many species are strongly associated with agricultural habitats (Pain & Pienkowski, 1997).

Baker & MacDonald (2000), based on a larger sample of Wiltshire farmers, found that 80% of arable, and 49% of mixed farms were managed by farmers with interests in shooting, figures comparable with the 62% found in this study. The relationship between farm size and game management is also consistent between the two studies. Farmers in the "game and landscape" category recognised an ecological value of field boundary vegetation, suggesting better awareness of the issues surrounding management of this habitat, but as with the other interest categories, this was not reflected in the management practices they adopted. Only those specifically expressing an interest in wildlife conservation, also claimed to be adopting positive behaviours. Farmers with high conservation interest scores also had a more favourable attitude towards bramble, nettle and umbellifers. However, their attitudes towards the beneficial perennial grasses, and the annual grasses and cleavers (seen as pernicious) were consistent with farmers with low conservation interest scores. However, even such high conservation interest scores did not produce desirable habitats in terms of the actual width or botanical composition of herbaceous vegetation strips.

These results suggest some understanding of agriculturally and environmentally desirable field boundary vegetation amongst farmers with game or wildlife conservation interests, but even amongst these farmers there is a reluctance to adopt wide herb strips, and a failure to achieve a desirable botanical composition within them. As outlined in chapter 4, socio-economic characteristics of farmers influence their approach to management of farmland features such as field boundaries. For example, Ellis *et al.* (1999) found that botanical composition of Scottish grassland was related to farmers' involvement in off-farm activities (pluriactivity), and age and educational background are known to influence farmers' conservation attitudes and behaviour (e.g. Lowe *et al.*, 1997). Some farmers explain their reluctance to intensify management of grassland in terms of a moral imperative and cultural identity (e.g. Burgess *et al.*, 2000). Such socio-economic and cultural influences have a considerable impact on the farmland landscape and specific factors relating to field boundary management require further and more qualitative investigation, especially in relation to the adoption of agri-environment schemes.

Agricultural advisors, the main influence on farmers' management decisions, appear to be associated with negative behaviour and narrow herb widths, and farmers who are most concerned about herbaceous strips as a source of arable weeds have strips with grass as a minimal component. There is therefore a need to inform farmers about the effective management of field boundaries for both agricultural and ecological objectives. There is also a need to provide similar information to advisors and to optimise their role as communicators of such information to farmers. Central to this is the recognition that farmers and conservationists, while both valuing hedges on farmland, differ in their perception of them (Oreszczyn & Lane, 1999).

7.4.4 Habitat management for whitethroats

In order to improve farmland habitat for whitethroats there is a need to consider the conflicting worldviews of farmers, formulating management advice that is consistent with either "cultural capital" or "progressiveness" interest categories, and if possible, both. The basic understanding associated with "game and landscape" interests could be developed, and the compatibility of the management of habitat for wild game with that for whitethroats and other farmland birds could be exploited. Farmers with "Game and landscape " interests were associated with the largest farms, and targeting this group could therefore result in improved habitat for whitethroats and other farmland wildlife over a wide area. However, addressing farmers with "cultural capital" and "progressiveness" interests could result in wider application of appropriate management across all farm sizes.

Perennial herbaceous vegetation limits establishment of arable weeds and supports invertebrate predators of crop pests. The establishment and maintenance of perennial herbaceous vegetation in field boundaries, rather than minimising its width, could provide economic benefits to the arable crops, have longer term benefits for farmland wildlife, and support farmers' shooting interests through the provision of gamebird nesting cover. As most farmers see shooting as a social, rather than an economic activity, this would be consistent with "cultural capital" interests.

Farmers with conservation interests may recognize less instrumental incentives for field boundary habitat management as the habitat supports perennial flowering plants and the butterflies which use them as a food source for both adults and larvae (Dover, 1996 & 1999). Invertebrates such as these are known to form a major part of the diet of breeding whitethroats and other farmland birds (Moreby & Stoate, 2000). Hedges with herbaceous vegetation are also primary habitats on farmland for small mammals such as harvest mice (Bence *et al.*, 1999; Brown, 1999; Harris & Woollard, 1990).

Management of perennial swards in field boundaries requires the application of modern methods and equipment that avoid misplacement of arable inputs. As such it is consistent with "progressiveness". As it is likely to result in reduced use of herbicides in arable crops, such management is likely to be unattractive to agrochemical company advisors, but its technical nature is perhaps more compatible with the interests of independent advisors. Because advisors have a major influence on farmers' decision making, information should be targeted at this group. Magazines also influence farmers when they are considering management of non-crop habitat, as well as commercial crops, and could play a central role in developing an approriate attitude towards field boundary management.

Chapter 8

Cultural ecology of Whitethroat (*Sylvia communis*) winter habitat management by farmers: farmland trees and shrubs in Senegambia

8.1. Introduction

West Africa is an important wintering area from many migratory bird species that breed in northern Europe. The whitethroat (*Sylvia communis*) is one of many which is known to winter in Senegal (Dowsett *et al.*, 1988). A substantial crash in breeding numbers of whitethroats in 1969 was associated with drought in this species' Sahel and Sudan wintering regions (Winstanley *et al.*, 1974). Baillie and Peach (1992) have since demonstrated that subsequent population limitation has been determined by over-winter survival and that this is correlated with rainfall in Sub-Saharan Africa.

Similar relationships have been demonstrated or suggested for other migratory species, and the importance of maintaining sites used by birds during migration or during the winter is widely accepted (Salathé, 1991). For species using traditional sites as staging posts during migration or in winter, such conservation can be targeted, but for species that are widely dispersed and mobile during the winter, conservation action must be fully integrated with human land use in the wider environment.

In their wintering areas, migratory passerines make greater use of unstable, savanna habitats than resident species (Alerstam, 1993). Whitethroats, in particular, avoid closed canopy forest, and occur in dry savanna and open woodland habitats, using more degraded habitats than other migratory species (Moreau, 1972). They feed on invertebrates in trees and shrubby vegetation (Moreau, 1972) and are mobile and often highly dispersed, with numbers at specific sites fluctuating through the winter in response to food abundance (Vickery *et al.*, 1999).

Whitethroats have been recorded foraging in a range of tree and shrub species in winter. Stoate & Moreby (1995) and Stoate (1995) found whitethroats in northern Senegal feeding on the berries of *Salvadora persica* and *Nitraria retusa* during pre-migratory fattening in March and early April. Whitethroats have also been observed at high density feeding on berries in January in a coastal strip of *Maytenus senegalensis* in The Gambia (C. Stoate, unpublished data). However, invertebrates appear to form a greater part of the diet in the mid-winter period and are likely to influence local movements and abundance of whitethroats, with this species normally being widely dispersed while they exploit this more dispersed food resource. Vickery *et al.* (1999), working at Nguru (northern Nigeria) in March and early April found whitethroats at densities of up to 1.6/ha in species rich open woodland. At this site in December-January, whitethroats were most abundant in relatively open country and correlated with abundance of the shrub, *Piliostigma thonningii* (Jones *et al.*, 1996 density: 0.7/ha; Stoate, 1997, density: 1.3/ha) a species supporting potential invertebrate food (Stoate, 1997). Similar relationships between bird abundance and area of woody vegetation supporting invertebrates have been shown for Olivaceous warbler (*Hippolais pallida*) (Stoate, 1998).

Drought in the Sahel and Sudan wintering area, resulting from declining rainfall since the late 1960s, has had considerable impact on the abundance of woody vegetation (Mortimore, 1989). Although this may result in the complete loss of suitable habitat in some areas, in others, degradation of woodland may improve this habitat for whitethroats at the expense of other species, particularly resident African species.

Trees and shrubs have a wide range of cultural, medicinal and other roles for people living in the Sudan and Sahel and can also minimise erosion of soil by wind and drought. The loss of woody vegetation from this region has been associated with increased erosion (Lal, 1996) and incidence of dust storms towards the end of the dry season, with dust storm frequency being strongly correlated with average annual rainfall over the previous three years (Middleton, 1985).

Although drought has been particularly severe since 1969, climate variability has long been a feature of the western Sahel, resulting in non-equilibrium ecosystems in which plant and animal populations are in almost constant flux, despite physiological and behavioural adaptation (Ellis, 1994). Farmers limit the effects of climatic uncertainty by adopting complex cropping systems incorporating a high diversity of crops, and of varieties within crops. Historically, a fallow period within the rotation was used to restore soil fertility and moisture. Farmers also keep livestock for which the immediate effects of drought can be reduced by the use of leaves from trees and shrubs as forage to supplement herbaceous vegetation.

The human population in the Sahel increased by 3% pa through the 1970s and 1980s, while food production per capita declined by 3% pa over the same period (Agnew, 1995). Attempts to increase food production have involved shortening fallow periods, clearing woodland and scrub to enlarge the area in permanent cultivation. For example, the cultivated area in northern Nigeria increased from 11% of the total areas in the mid 1950s, to 34% in 1990 (Mortimore, 1995). Such changes are accompanied by other factors such as increased use of fertilisers where these are affordable, and increased livestock grazing densities.

Together these have reduced the area of mature woodland and regenerating scrub, increasing the area exposed to wind erosion, and reducing the area of suitable habitat available to wildlife. Loss of woody vegetation is therefore a result of agricultural activity, as well as drought but the interaction between these two factors is complex and some authors have attributed the decline in rainfall, in part, to deforestation, through the resulting albedo effect (e.g. Bouwman, 1990; Pearce, 1997; Sanderström, 1995).

The degree to which extensive loss of woodland is the cause or the consequence of particular forms of human activity in West Africa, and the current role of industrialised countries (e.g. through contributions to climate change), remain unresolved. However, changes in farming methods could have a substantial negative impact on both the sustainability of farming systems, and the suitability of this habitat for a range of Palearctic birds that depend upon trees for roosting and foraging.

Scherr and Hazell (1994) describe the process of environmental degradation as the human population density increases, followed by a period of environmental improvement as the population continues to increase. This 'induced innovation', proposed by Boserup (1965), is illustrated by examples from Kenya (Scherr and Hazell, 1994) where increased tree cover was a central component of environmental improvement associated with increasing population density. Trees increase the diversity of products obtained from farmland, enhance food security, minimise soil erosion, optimise soil nutrient status, and provide fencing materials and food for livestock, as well as having cultural and medicinal values.

However, improving the sustainability of farming systems, including incorporation of trees into those systems, is dependent on a number of factors. Where long-term tenure, or the potential for subsistence is not secure, the incentive to invest in capital land improvements will not be present. Lack of local knowledge or communication of knowledge from elsewhere may be particularly important constraints in recently settled areas or during periods of rapid land use change, and access to the necessary inputs is essential (Scherr & Hazell, 1994). Income from other sources, for example through access to local employment in towns, can influence the latter. State funded research into appropriate technology can improve the relevant knowledge, but it is rare as funding is channelled into cash crop research at the expense of small-scale farmers growing dryland food crops (Benneh, 1996).

This chapter investigates the use by farmers of savanna farmland, and in particular the trees and shrubs that provide potential foraging habitats for whitethroats. It aims to identify incentives for the management of woody vegetation on farmland to benefit both farmers and birds such as whitethroats. Such a process may apply equally to other migratory and non-migratory passerine species occupying woodland habitats and woody vegetation on farmland.

8.2 Methods

8.2.2 Study area

The study area comprised approximately 20 km^2 of mainly open farmland savanna spanning the Gambia/Senegal border close to Fass (16°27'W 13°35'N). For simplicity, the area is here called 'Fass', although in reality this name applies only to the small town. The area is on the southern edge of the Sudan vegetation zone and approximately on the 900-mm isohyet. The area includes three villages (labelled A-C here), and the people are mainly Mandinka with larger numbers of Serer and some Wolof in village C. Part of the area is farmed by Tourka (of Burkino Faso origin) from a neighbouring village outside the study area. The main crops are groundnut (mainly *Vigna subterranea*) and pearl millet (*Pennisetum glaucum*), although sorghum (*Sorghum bicolor*) is also grown.

The current land tenure system gives exclusive rights for growing crops to individuals, normally heads of compounds. These rights are extended to the fruit and other products of planted trees such as Cashew (*Anacardium occidentale*) and Mango (*Mangifera indica*), although the latter are rarely planted on farmland because of browsing problems. Such rights do not extend to naturally occurring trees, the products of which can be gathered by anyone. Residents of the three villages in this study can obtain many tree products in uncultivated areas and on other peoples' farms (although to a lesser extent than in the past), and the incentive to plant or encourage regeneration of trees on farmed land is therefore generally lacking.

As the area has been cleared of forest during the course of the twentieth century, it does not have a long tradition of arable cultivation. All three villages have access to seasonally flooded riparian land which remains wooded but where irrigated gardens have been created for the production of vegetables for both domestic use and sale. These gardens are managed almost exclusively by women, while the dryland farmland which forms the subject of this paper is managed mainly by men, especially in the case of Mandinka families. Some people have regular or occasional paid work outside the village. Male farmers without access to such work are therefore amongst the poorest members of the community, and have difficulty meeting traditional cultural obligations such as dowries, naming and initiation ceremonies. Livestock kept on the farmland during the day are housed within village compounds at night. Their dung is used to manure small fields next to the village, and is carried to the seasonally flooded land for use on gardens. Very little is available or used on farmland.

8.2.3 Habitat use by whitethroats

Point counts were used to determine whitethroat presence or absence in relation to tree and shrub cover in January, 1998. Point counts were carried out at 100-m intervals along nine 1-km parallel transects through open farmland savanna and separated by a minimum of 200-m. Farmland lacking any woody vegetation and areas of dense woodland were avoided. After walking to the count point, three minutes were allowed for the birds to settle before the count was started. Over a two-minute subsequent period whitethroats were counted within a 25-m radius of each point (estimated by pacing). Tree species (Maydell, 1990), height and maximum canopy width were also estimated (to the nearest metre) within each 25-metre radius. Tree numbers within a 25-m radius at each point were used to calculate tree density, and overall cover for each point was calculated from canopy diameter of trees and shrubs.

Point counts in open farmland savanna are known to be close to complete counts (Vickery *et al.*, 1999) and to density estimates derived from distance sampling (Stoate, 1997), and whitethroat counts in this study were therefore used to estimate density for farmland with high and low shrub cover. The relationship between whitethroat presence and absence and abundance of woody vegetation was explored using logistic regression.

Invertebrates were collected from five tree species in January 1998 and 1999. The tree species selected for sampling were all abundant in the area, two of them being planted for their fruit (*Anacardium occidentale* and *Mangifera indica*), two being common indigenous regenerating species on farmland (*Guiera senegalensis* and *Lannea sp.*), and one being a naturalised Asian species (*Azadirachta indica*). Other species were not sampled because they were scarce or present only as low regenerating vegetation. One invertebrate sample per plant (n=20) was collected from the lower canopy of trees, and the upper branches of shrubs, in the early morning using a 35 x 53-cm beating tray. Because of the vertical structure of most species, foliage immediately above the tray was bent over and shaken for approximately five seconds per sample. The contents of the tray were then quickly transferred to a plastic bag. Within one hour of collection, invertebrate samples were stored in 70% alcohol for subsequent identification. The invertebrate groups recognised were ants (Formicidae), beetles (Coleoptera), caterpillars (Lepidoptera), plant bugs (Miridae), plant hoppers and leaf hoppers (Homoptera), spiders (Araneae) and miscellaneous invertebrates. Differences in invertebrate numbers (log-transformed) between tree species were compared using ANOVA.

8.2.4 Habitat management by farmers

A Serer interpreter, resident in village A, was used in all discussions with farmers which initially took the form of basic information gathering exercises with a small number of individuals, including elders and other farmers. This background information formed the basis for subsequent work. In September 1998, a historical matrix (Schoonmaker-

Freudenberger, 1993 & 1994) was used to establish, more formally, historical background information relating to changes in farming practices since the 1950s. A matrix was created with the help of a group of elders with agricultural expertise in each of the three villages within the study area. Participants were asked to place up to ten groundnuts in each cell for each decade (columns), and for each of the categories (rows) (Table 8.1). When the matrix was complete, participants were asked to place up to ten groundnuts against each of the rows to indicate to what extent the reported changes were desirable or undesirable.

In village A one group of five women and one group of four men provided information on the uses and relative values of six tree species using pair-wise comparison (Pretty & Scoones, 1989). The men had contributed to the historical matrix, while the women were primarily gardeners with a peripheral involvement in dryland farming. Because the area has only relatively recently been cleared from forest supporting numerous tree species, the species used for the pair-wise comparison were restricted to those still abundant as trees or low regenerating vegetation, or known from previous research to be used by insectivorous birds such as whitethroats (Table 8.2). Photographs of the trees and local names were used for comparisons. Participants were presented with each pair of trees in turn and asked to say which was the preferred, explaining the reasons for their choice. This process produced a list of uses for each tree species which formed the basis for a wider survey of farmers. Scores derived from summing the number of times each species scored higher than its pair enabled the species to be ranked for men and women.

Table 8.1. Explanation of categories adopted for historical matrices in the three villages. Participants used groundnuts to represent changes in the decades 1950s-1990s.

Category	**Description**
Tree cover	Area of land covered by trees of all species
Shrub cover	Area of land covered by shrubs of all species
Fallow area	Area of farmland in fallow in any one year
Fertiliser use	Amount of artificial fertiliser used on crops
Crop yields	Groundnut and millet production per unit area of farmland
Cow ownership	Number of cows owned by farmers within the village
Use of fire	Frequency of burning to clear land for cultivation
Wildlife abundance	Numbers of wild birds and mammals of all species
Human population	Number of village residents

Table 8.2. Criteria used for the selection of tree and shrub species for pair-wise comparison and use-value matrices.

Tree species	Local abundance	Use by whitethroats
Guiera senegalensis	Very common	Insect-rich foraging habitat
Piliostigma thonningii	Scarce	Insect-rich foraging habitat in Nigeria (Stoate, 1997)
Azadirachta indica	Very common and invasive	Low invertebrate abundance
Daniella oliveri	Common. High levels of regeneration	Not used.
Combretum glutinosum	Very common. High levels of regeneration	Not used
Faidherbia albida	Very scarce	Insect-rich foraging habitat (Stoate, 1998)

In order to obtain information from a random selection of active farmers, semi-structured interviews were conducted with 29 farmers (24 men and 5 women) while they were weeding on their farms. September was chosen as the month in which most farmers would be engaged in this activity and a representative sample could therefore be obtained by walking a set route across the study area. Farmers were asked the same open-ended questions, with additional questions being asked where these were prompted by their answers. Each farmer was asked to state their farm size, and the number of cows and machines they had. They were also asked what were the main constraints limiting food production for their families.

Using the same method as for historical changes in farming methods, each of the 29 farmers was then asked to create a use-value matrix for the six tree species used in the pair-wise comparisons. Photographs, fresh specimens and local names were used to identify trees. Based on previous discussions with farmers, the potential uses incorporated in the matrix were fuel, timber, medicine, food, fodder, and culture (e.g. use in cultural ceremonies etc). A category 'farming' was added to assess any perceived benefits of each tree species to crop production. Overall scores for each tree species and farmer were derived by summing scores for each use category.

The results of this process were then used to guide a literature review, the results of which were presented to village elders in the three villages in January 1999. The potential for practical application of incorporating trees and shrubs into the cropping system was discussed.

8.3. Results

8.3.1 Habitat use

No whitethroats were recorded using trees. However, there was a positive relationship between whitethroat occurrence and total shrub area ($R = 0.458$, $P<0.001$, $n=90$), and with the area of the shrub species *G. senegalensis* ($R = 0.303$, $P<0.01$, $n=90$).

Whitethroats were absent on farmland with low shrub cover (<399m^2 ha^{-1}), but were present at a density of 1.02 birds ha^{-1} on farmland with higher shrub cover. Whitethroats were present in insufficient numbers to conduct point counts in 1999, although *G. senegalensis* was the only shrub species used by the birds seen.

Total invertebrate abundance differed significantly between years ($F_{1,112} = 9.28$, P=0.003), with a significant year•species interaction ($F_{2,112} = 4.32$, P=0.016). Significant year differences were also apparent for ants ($F_{1,112} = 7.71$, P=0.006), caterpillars ($F_{1,112} = 23.26$, P<0.001) and others ($F_{1,112} = 6.94$, P=0.01). Caterpillars and spiders were significantly more numerous in *G. senegalensis* than in any of the other tree species in both years while Miridae and Homoptera were more abundant in *Mangifera indica* and *Anacardium occidentale* respectively (Table 8.3).

8.3.2 Habitat management

8.3.2.1 Historical matrices

All three villages reported increases in the human population, the use of fire, and plough ownership. Increases in the population and in the number of ploughs were considered to be desirable in all villages, consistent respectively, with the centrality of family growth in Muslim tradition, and the need to cultivate larger areas as soil fertility declines. Village A considered the increased use of fire to be desirable, while the others claimed that it was not. Participants in villages B and C claimed that fires were started accidentally, to the north of the study area, possibly by honey gatherers.

All villages reported declines in tree abundance, shrub area, fallow area, inorganic fertiliser use and wildlife abundance and considered these declines to be undesirable. Whereas there is now a clear view from each of the villages across open savanna, thirty years ago the area was much more wooded close to the villages and 'bush meat' made a more frequent contribution to the diet. Village A village reported fluctuating rainfall and crop yields, while the other villages reported declines in both. All villages considered the changes reported to be undesirable. Village C reported an increase in cow numbers while the other villages reported declines because of disease problems. All villages considered increasing cow numbers to be desirable.

8.3.2.2 Tree uses and values

Pair-wise comparisons of tree species suggested the following broad use categories - fuel, timber, medicine, food, fodder, and culture, which with the addition of 'farming' formed the basis for the categories used in subsequent matrices. Table 8.4 shows ranking of trees resulting from the initial pair-wise comparisons with men and women, and the matrices completed by farmers.

Table 8.3. Invertebrate abundance in samples (mean ± se) from *Guiera senegalensis* and four other abundant tree species (1998 & 1999). For each tree species symbols beneath the means represent higher (+) or lower (-) invertebrate abundance compared to *G. senegalensis*. +++/--- = P<0.001, ++/-- = P<0.01, +/- = P<0.05.

	Guiera senegalensis	*Mangifera indica*	*Anacardium occidentale*	*Lannea sp.*	*Azadirachta indica*	$F_{4,70}$	P
1998							
Ants	1.73 ± 0.42	0.20 ± 0.14 --	0.60 ± 0.34 -	1.00 ± 0.48	1.87 ± 0.53	4.21	0.004
Beetle	0.53 ± 0.19	1.73 ± 0.45 +	0.73 ± 0.23	2.07 ± 0.68 +	0.40 ± 0.30	3.37	0.014
Caterpillar	1.07 ± 0.23	0.00 ---	0.00 ---	0.00 ---	0.00 ---	19.41	<0.001
Miridae	0.00	0.47 ± 0.19 +++	0.00	0.00	0.00	6.48	<0.001
Homoptera	0.00	0.00	3.33 ± 1.31 +++	0.00	0.00	10.01	<0.001
Spider	2.00 ± 0.54	0.33 ± 0.23 ---	0.53 ± 0.24 --	0.27 ± 0.12 ---	0.27 ± 0.12 ---	5.57	0.001
Other	0.07 ± 0.07	0.27 ± 0.15	0.27 ±0.12	0.33 ± 0.16	0.00	1.62	0.18
1999							
Ants	1.47 ± 0.69	0.13 ± 0.09 -	0.13 ± 0.09 -	0.53 ± 0.27	1.47 ± 0.58	2.65	0.04
Beetle	3.13 ± 1.16	14.2 ± 3.04 +++	5.20± 1.88	2.33 ± 1.60	0.27 ± 0.15 +	9.93	0.001
Caterpillar	0.80 ± 0.24	0.00 ---	0.00 ---	0.00 ---	0.00 ---	13.54	<0.001
Miridae	0.00	0.267±0.15	0.00	0.00	0.00	2.45	0.054
Homoptera	0.00	0.07 ± 0.07	7.00 ± 3.09 +++	0.00	0.00	18.98	<0.001
Spider	1.53 ± 0.38	0.07 ± 0.07 ---	0.67 ± 0.25 --	2.00 ± ---	0.13 ± 0.09 ---	8.84	<0.001
Other	1.00 ± 0.30	4.40 ± 1.37 ++	0.53 ± 0.22	0.00 -	0.00 -	11.23	<0.001

Matrices revealed that overall use-values for *Faidherbia albida* and *Combretum glutinosum* were lower than for the other species. The preferred species were valued for a wide range of uses, of which medicinal uses were the most important (Figure 8.1, Table 8.5). Trees were perceived to have little value for farming, reflecting the results from pair-wise comparisons in which farming was not mentioned. The ranking of tree values was more closely related to that for the group of men than that of women, perhaps reflecting the sex ratio in this sample of farmers. This was, however, a representative sample of farmers involved in weeding (including the removal of regenerating woody vegetation) at the time of the interviews.

Many tree species are used for timber and fuel while other uses are more specific to tree species. Of the three species known to be used as foraging habitat by whitethroats, tree value matrices prepared by farmers revealed that *G. senegalensis* was valued more highly than the other two for its medicinal uses (Wilcoxon $Z>4.78$, $P<0.01$, $n=29$). *P. thonningii* was more highly valued than other species except *D. oliveri* for its cultural values, especially the use of branches and dye in Serer and Mandinka initiation ceremonies ($Z>1.97$, $P<0.01$, $n=29$). Despite its scarcity in the area, *F. albida* was more highly valued than all other species for its use as fodder ($Z>3.06$, $P<0.01$, $n=29$).

Table 8.4. Ranking of tree use-values identified by a group of men and a group of women (pair-wise comparisons), and random sampling of working farmers (use-value matrices). Rank 1 = desirable, 6 = undesirable.

	Pair-wise comparisons		Use-value matrices
Rank	Men	Women	All farmers
1	*Daniella oliveri*	*Guiera senegalensis*	*Daniella oliveri*
2	*Azadirachta indica = Piliostigma thonningii*	*Combretum glutinosum*	*Piliostigma thonningii*
3	*Guiera senegalensis*	*Daniella oliveri*	*Guiera senegalensis*
4	*Combretum glutinosum*	*Piliostigma thonningii*	*Azadirachta indica*
5	*Faidherbia albida*	*Azadirachta indica*	*Faidherbia albida*
6		*Faidherbia albida*	*Combretum glutinosum*

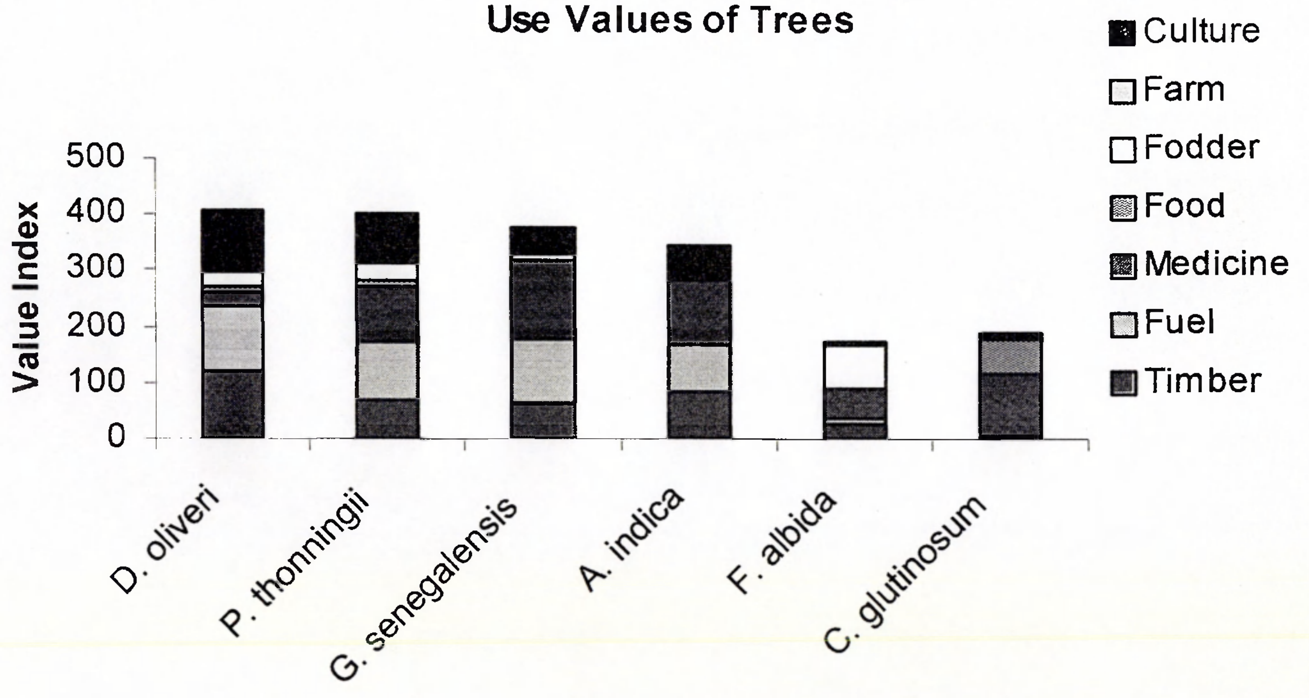

Figure 8.1. Use values of six common tree species, based on scores derived from matrices prepared by 29 farmers weeding groundnut fields.

Table 8.5. Uses identified by 29 farmers for six common tree and shrub species.

Tree species	Medicine	Fuel	Timber	Fodder	Food	Culture	Farm
Daniella oliveri	Flowers for bad teeth & for wounds. Roots for cough & asthma.	Good fuel.	Wood for boats & furniture.		The best nectar source for honey bees (and children).	Sap aromatic when burnt. Flowers used in weeding ceremony. Boiled flowers expel bad spirits.	
Piliostigma thonningii	Flowers used as eye wash, leaves for healing wounds & sore throats. Stems used against cancer & TB. Boiled leaves & roots For stomach ache.		Bark used as rope.		Flowers impart lemon flavour to food. Fruit can be eaten.	Branches & dye from bark used in initiation ceremony & leaves for washing after circumcision. Three stems in house ward off spirits.	
Guiera senegalensis	Boiled roots for coughs and chest pains. Roots aphrodisiac for men.					Branches put on graves & round waist for safe journey. Roots used to prevent large storms.	
Azadirachta indica	Soap made from fruit relieves skin diseases. Inhale steam from boiled leaves for headache.	Good fuel.	Roof rafters & beds.				Fencing. Used as insecticide spray in small gardens (not on farmland)
Faidherbia albida	Flowers boiled for rashes & washing. Leaves boiled for toothache.	Good fuel.		Leaves and fruit for cows		Bad luck for nursing mothers to sit under canopy.	
Combretum glutinosum	Roots boiled for eye wash & skin diseases & wrapped round waist for aching waist. Also cure yellow fever. Boiled flowers used for skin diseases.				Seeds used as famine food.	Used for masks in initiation ceremony.	

8.3.2.3 Farmer interviews

Farm area varied considerably between farmers with most farms being less than 10 ha. A discrete group of Tourka managed farms of more than 50 ha. Farmers with large farms generally also owned the most cows ($r_s = 0.549$, $P<0.01$, $n=29$). Most farmers owned at least one plough, with the number of ploughs owned being related to farm size ($r_s = 0.523$, $P<0.01$, $n=29$). Only seven of the twenty-nine farmers interviewed still incorporated fallow into their farming system, representing 10% of the farmed area. Some farmers mentioned that the availability of machines (ploughs and seed drills) was a constraint now that it was necessary to work a larger area.

Twenty-six farmers claimed that declining soil fertility was the greatest problem affecting their ability to produce enough food for people in their compounds and that this has become a very serious problem. Most said that, although they had used fertiliser in the past, this was now much too expensive. Of the three farmers for whom declining soil fertility was not a problem, one maintained half of the farm in fallow and another owned high numbers of cows which were kept on the farm in the dry season. The third had some cows and a donkey cart which was used for transporting household waste from the village.

8.3.3 Literature search and practical application

A literature search revealed potential action for alleviating the problem of declining soil fertility, as well as providing foraging habitat for whitethroats and other Palearctic migrant warblers. *Faidherbia albida* is highly valued in other farming communities in West Africa where its regeneration is encouraged because of its role in maintaining soil fertility (Wood, 1989; McGahuey, 1992; Hervouët, 1992). Pelissier (1966) described an established cropping system incorporating the management of *F. albida* by Serer in the main groundnut-growing region of Senegal. The soil-improving qualities of this species arise because deep-rooting enriches surface soil by drawing minerals from lower horizons and leaf litter increases soil organic matter and enhances microbial activity (Sall, 1992). *F. albida* has particular potential for restoring nitrate levels because of nitrogen-fixing *Bradyrhizobium* on its roots (Dupuy & Dreyfus, 1992). It is unusual in that leaves are shed at the start of the rainy season. It therefore does not shade crops growing beneath it, and yet provides leaves during the dry season when they are most needed by livestock. Both fruit and leaves have considerable value as livestock fodder and have a high protein content (Reed *et al.*, 1992; Cissé & Koné, 1992). This and other Acacias are known to have considerable value as a foraging habitat for warblers (Moreau, 1972; Morel & Betlem, 1992; Stoate, 1998).

Piliostigma reticulatum, a species closely resembling *P. thonningii* and similar in its uses (Maydell, 1990), is regarded as the third most important tree species on farmland by farmers in the Kaolak area of Senegal, to the north of the Fass study area, only *F. albida* and *Cordyla pinnata* (not present at Fass) being more important (Diack, 1998). The reason for this is the contribution this species makes to soil organic matter, thereby improving moisture retention and microbial activity. Mandibaya & Chihora's (1999) nutritional analysis of *P. thonningii* confirms the value of this species as supplementary livestock fodder. As well as benefiting from this food source, livestock deposit dung close to the bushes, further increasing soil fertility and organic matter. Sall (1998) and Schoonmaker Freudenberger (1993) reported the use of *Combretum glutinosum* as part of some farmers' soil management. These farmers claim that soil organic matter is higher close to *C. glutinosum* trees and that arable crop yields are higher than where there are no trees. Similar properties are claimed for *G. senegalensis*, and Wezel and Bőcker (1999) reported millet yields that were 68-94% higher in plots mulched with branches from this species than in control plots.

8.3.4 Discussion groups

In January 1999 the three villages were revisited and an informal discussion was held with the same groups of elders as in the previous September. At village A, elders were interested in the potential role of trees and shrubs in alleviating soil degradation and improving fertility but felt that their value as fodder was not relevant to them because of the low numbers of cows they were able to keep because of disease problems. In addition, shrubs occupied space that would otherwise be used for growing crops and were likely to be destroyed by fire in the dry season.

At villages B and C, some elders agreed, on reflection, that crop yields were sometimes higher close to *G. senegalensis* bushes, but as in village A, they felt that bushes would be destroyed by fire and occupied valuable space. The potential for using *F. albida* was of more interest to elders in all three villages, because it 'makes fertiliser', is leafless when crops are growing, and produces leaves and fruit during the dry season. This latter benefit was most relevant to the people of village C where cow numbers are higher. At village A, one elder was enthusiastic about attempting to grow *F. albida* from seed and asked for information on cultivation methods. At villages B and C, the elders agreed to consider doing so. However, there was a strong feeling at village C that they should have a right to continue farming as in the past, with considerable use of fertiliser and fire, and with any short-comings (e.g. fertiliser costs) being met from government funds.

One farmer at village A subsequently planted seeds in pots (following scarification pre-treatment (Wood, 1989) which improved germination) and grew young trees for planting on his farm. *F. albida* seedlings were also discovered growing on his farm through natural regeneration, and whereas previously these would have been destroyed, the saplings were protected from browsing and allowed to grow.

8.4. Discussion

Whitethroats were strongly associated with shrub cover where invertebrates were available as potential food. *G. senegalensis* supported consistently more caterpillars and spiders than the other tree species sampled, and although the winter diet of whitethroats is poorly documented, these invertebrate groups are known to form a large part of the diet of whitethroats in the breeding season (Moreby & Stoate, 2000). The association of whitethroats with *G. senegalensis* in winter is likely to be a consequence of the abundance of potential invertebrate food there. This association between abundance of whitethroats and high invertebrate abundance in shrubs is consistent with previous studies of this species on degraded savanna farmland and woodland habitats in mid-winter (Stoate, 1997; Vickery *et al.*, 1999).

Mann (1975), working near the Fass study site, reported a substantial decline in the area of woodland, and its replacement by shrubby savanna between 1946 and 1968. Two-storey forest declined from 25% to 5% of the total area in this period. Agricultural land without woody vegetation increased from 18% to 25%, including an increase in continuous cropping from 0% to 15%, while shrubby and woodland savanna increased from 57% to 70%. This represents a slight increase in the area of suitable whitethroat habitat up to 1968 and is in accordance with the changes in tree numbers reported by farmers in this study.

Farmers in this study reported a continuing decline in the area of trees, shrubs and fallow land in the subsequent 30 years, suggesting an increase in the area of open land lacking shrubs and trees and representing unsuitable habitat for whitethroats. In a protected, more wooded area (Fathala Forest) immediately to the north of the Fass study area, Lykke (1996) investigated changes in tree abundance within living memory, using semi-structured interviews with local people. This survey confirmed a continuing decline in trees over the past thirty years, in spite of the government protection given to this site.

In her study, Lykke (1996) found that tree species that were most valued by local people were the species to have declined most severely, including *D. oliveri,* the species most valued in the current study. *D. oliveri* regenerates through profuse production of root suckers, but Lykke found that recruitment to the population was very low, with a predominance of large trees, a situation also observed at Fass. This lack of young trees was common to other preferred species and was explained by the frequent occurrence of fire.

The use of fire has increased as a tool for clearing quickly and cheaply the larger areas now necessary for cultivation following increases in the human population and diversion of women's labour to more profitable gardening. The use of fire is likely to reduce severely the regeneration of many tree and shrub species. Fire is known by farmers to be discouraged by the authorities and informal discussions with farmers suggested that this was the most likely reason for the disparity between villages in the reported desirability of this practice. Of the three villages, the one claiming it was a desirable farming practice was the one in which the interviewer lived, and with which he had the greatest rapport.

Regeneration of many tree species is also restricted by the removal of saplings during the weeding process in September, and the increased use of ploughs may have contributed to increased destruction of regenerating trees. *G. senegalensis* appears to have the capacity to regenerate rapidly each year, but even for this species, replacement of a fallow rotation with continuous cropping could result in weakening of regenerating plants. *P. thonningii* also regenerates readily from rootstock, but unlike *G. senegalensis*, produces seed only as a mature tree and very few of these were present at Fass. A decline in the abundance of *P. thonningii* was noted and regretted by elders at village B who felt that it had been over-exploited because of its many medicinal and cultural uses, rather than being preserved for its value in this respect.

The difference between tree value rankings for the small groups of men and women is interesting. *D. oliveri* and *P. thonningii* were valued by men for their cultural uses (Table 8.5), and in the case of *P. thonningii*, also for the rope produced from its bark. The equal ranking of *P. thonningii* and *A. indica* followed a long discussion in which the stems of coppiced *A. indica* were valued for their use in the making of fences and tree guards for mango saplings, but only if *P. thonningii* bark was available to tie them together. The women, on the other hand placed greater emphasis on the medicinal values of *G. senegalensis* and *C. glutinosum*. These species were regarded in some respects as weeds by the men, who were responsible for clearing land for cultivation.

In common with the farmers contributing to Lykke's study, those at the three villages in this study failed to identify a role for trees and shrubs in maintaining or restoring soil fertility when interviewed, but in later discussions there was some recognition of this value. A role for shrubby vegetation in minimising wind erosion was not recognised and the potential for increasing shrub area was, in any case, limited by the occurrence of fire.

The value of species such as *F. albida* and *P. thonningii* for livestock was not a major consideration at villages A and B because of the low numbers and high mortality of cattle there.

Medicinal plants continue to play an important part in the lives of these people, as pharmaceutical products are too expensive for many. Laboratory studies have confirmed indigenous knowledge of such properties. *G. senegalensis* has antimalarial (Benoit *et al.*, 1996), antimicrobial (Sanogo *et al.*, 1998a) and antitussive (Sanogo *et al.*, 1998b) qualities, while *P. thonningii* has antihelmintic (Asuzu *et al.*, 1999) and antibacterial (Ibewuike *et al.*, 1997) qualities, as well as its fodder and cultural values. However, an increasing influence of American and European culture and values is now relayed to rural villages by young people working in towns where they have access to television and are isolated from ecosystems in which their cultures developed. This leads, to abandonment of some indigenous cultural practices, removing the incentive to maintain populations of tree species such as *P. thonningii*. Cultural values are fluid, and socially contested through such processes as prestige, stigma and group allegiance and can have substantial implications for the management of farmland landscapes (Chapter 4). Improving the transmission of indigenous cultural values over homogenisation of global cultures is likely to have agricultural and ecological benefits.

For the three tree species used by whitethroats, encouraging natural regeneration by avoiding clearance of some saplings during weeding, and by protecting from livestock, may be the most effective method of increasing tree numbers. Because of the current tenure system, it would be necessary to mark trees in order to ensure that others do not harvest them or their products. As land tenure becomes more permanent with increasing population, distinctions between land tenure and tree tenure may decline (Warner, 1995), providing more opportunities for encouraging trees on farms. The use of fire for clearing land prior to cultivation, and the use of ploughs for cultivation and weeding, inhibit tree regeneration and incentives to plant trees. Addressing these issues is essential to restoring woody vegetation.

Natural regeneration of *F. albida* has been found to be the most effective method of establishing this species at other sites (Wood, 1989). As the fruit are favoured by ruminants and only a third of seeds ingested are digested (Cissé & Koné, 1992), livestock serve to encourage dispersal. The findings of Lykke (1996) suggest that for some tree species, currently represented at Fass only by large mature trees, their continued presence is unlikely. Some of these (*e.g. Ficus spp.* and *Parkia biglobosa*) are of considerable value to people and to non-migratory birds and other wildlife and the cultural and practical value, use and management of these scarcer and declining species requires investigation.

Conclusions

Chapter 9.

Conclusions and Practical Application

Although specifically targeted management of farmland habitats has recently been demonstrated to result in increased breeding abundance of single species (Aebischer *et al.*, 2000), the management and research presented in chapter 5 are innovative in two important ways. Firstly, they examine and demonstrate conservation benefits to a complete passerine community (rather than a single species), and secondly these benefits arise from landuse that is primarily designed for reasons other than the conservation of farmland passerines. This study therefore illustrates the conservation potential for integrated multifunctional landuse within farming systems.

The findings suggest that farmers' shooting interests can be translated into conservation benefits for nationally declining farmland bird species through the adoption of an appropriate game management package. The reasons for this are not fully understood, and are likely to differ between bird species. Both wild and reared game management are associated with winter feeding and planting of gamecrops which provide food for passerines in winter. As increases in winter mortality are thought to have driven the declines in numbers of many farmland birds (Peach *et al.*, 1999; Siriwardena *et al.*, 1999), any game management system that increases survival by providing supplementary feed could contribute to bird conservation. However, the relationship between supplementary feeding, survival and breeding densities is poorly understood.

On the other hand, wild game management, as implemented at Loddington, involves a wider range of management practices and the benefits to birds could therefore be greater than those associated with that of reared game. For example, the maintenance of field boundary vegetation as nesting cover for gamebirds also benefits whitethroats and yellowhammers (chapter 6). A market for wild gamebird shooting is not yet established as numbers of gamebirds killed on shoot days are lower than on reared gamebird shoots and current social norms dictate that shoot days are judged largely by the number of birds killed. The uptake of game management for wild gamebirds is confined to those farmers and landowners who appreciate the different type of shooting that wild gamebirds provide, and the wildlife benefits that are associated with it. While the conservation benefits of farmland managed for reared gamebirds could be considerable, the additional benefits associated with the management of wild gamebirds can only be realised if there is a widespread change in the cultural values of the shooting public. The novelty of this approach and increasing environmental awareness could result, through the social processes described in chapter 4, in the evolution of revised values and a new culture of landscape management.

Incentives for shooting are often social rather than economic (chapter 7) and farmers who are interested in shooting tend also to be more interested in wildlife than farmers who do not have shooting interests (MacDonald & Johnson, 2000). In addition, as farmers' interest in wildlife is increasing (Wesmacott & Worthington, 1997; MacDonald & Johnson, 2000), adoption of wild game management could increase. This reasoning assumes a change in farmers' attitudes, rather than changes in the market for shooting, although it also assumes that farm businesses are sufficiently profitable to support such supplementary interests, or that economic support is available for management practices, for example through agri-environment schemes. However, encouraging farmers' own game interests is likely to achieve conservation benefits for farmland birds at less cost to the taxpayer than large scale specific targeting of management for these species alone. Agri-environment schemes can also be regarded as a training exercise and a mechanism for changing farmers' attitudes to resource use on farmland.

Management practices that benefit farmland birds are likely to be most attractive to both farmers and policy makers if they have multiple benefits. Policy makers also require benefits to the taxpayer as well as to the farmer. This combination of environmental benefits is possible. Recent changes in agricultural practices have been associated with a wide range of environmental problems concurrent with the declines in farmland birds that form the focus of this thesis (Chapter 2). In Senegambia, such environmental problems are primarily associated with increasing soil erosion and declining soil nutrient status (Chapter 8). In Britain, soil erosion is also a major environmental problem, although the costs are externalised from the farming system in the form of sedimentation of watercourses and deterioration in the quality of water and aquatic ecosystems (Pretty *et al.*, 2000). Agri-environment policies intended to alleviate these problems are likely to have multiple benefits, or could be designed with this objective.

Hedge removal, autumn cultivation and application of pesticides are practices that are associated with increased soil erosion and water pollution (Van Oost *et al.*, 2000; Skinner & Chambers, 1996; Environment Agency, 1999), as well as with declines in farmland birds. Birds are affected by loss of breeding habitat, loss of winter foraging habitat, and depletion of seed and invertebrate food. Landuse systems that maintain hedges and their associated vegetation, reduce autumn cultivation, and minimise pesticide use are therefore likely to be multifunctional in terms of their benefits.

Soil erosion in West Africa has direct agricultural effects in the form of declining crop yields. Malthusian theory states that finite resources will be exhausted as the human population increases and less sustainable methods are adopted, but Boserup (1965) and some recent authors argue that rising human populations inspire innovation and development of alternative methods. There is some limited evidence for this in Africa. Where this occurs, it is largely through the initial adoption of participatory work with farmers and the communication of indigenous knowledge between communities (Reij *et al.*, 1996).

My study of whitethroat habitat management identifies the potential for multifunctionality in land use, including benefits to whitethroats. In Senegambia, planting or natural regeneration of indigenous tree and shrub species represents one means of alleviating soil erosion and enhancing its nutrient status, while at the same time having cultural and medical benefits and providing wintering habitat for whitethroats. In

England, the perennial herbaceous vegetation required by breeding whitethroats also provides nesting habitat for gamebirds and wintering habitat for beneficial invertebrates, and helps to reduce the incidence of weeds in adjacent crops. Increasing interest amongst farmers in Integrated Farming Systems for moral and economic reasons (Drummond, 2000) may lead to an increase in this perennial vegetation in field boundaries in future. These field boundary strips of perennial vegetation also have an aesthetic value, according to the values and interests of the farmers responsible for their management, and other 'users' of the farmland environment. Such subjective values and interests are culturally determined and susceptible to evolution (Chapter 4).

Chapter 3 described the processes by which changes in agricultural practice can influence breeding abundance of farmland birds. The main message of chapter 2 is that such changes have not been confined to the recent past (i.e. living memory), but have been occurring throughout the history of agricultural development. It is reasonable to assume that changes in bird numbers have occurred over the same period and that the composition of bird communities has been in constant flux. Current conservation targets focus on restoring numbers of specialist farmland bird species to the population levels recorded in the 1970s (MAFF, 2000). This is a value judgement determined by limited availability of historical data. Other judgements, favouring bird communities quite different from those of the 1970s might be equally valid. Such targets might be set, not only at national level by policy makers, but at the farm scale by farmers themselves.

Lobley and Potter (1998) found that farmers entering two agri-environment schemes in southeast England differed in their attitudes to conservation. Those entering the Environmentally Sensitive Area scheme, which aims to avoid intensification of farming systems by prescriptive restrictions, did so on mainly economic grounds. Farmers entering the Countryside Stewardship Scheme, which offers a range of specific management options, were more conservation oriented and shared the conservation objectives of the scheme. The flexibility of the Countryside Stewardship Scheme enabled farmers to select management practices that best suited their own conservation and other objectives and enabled them to realise these within the objectives of the scheme. However, within current agri-environment schemes there is little scope for monitoring conservation benefits, and where this has been possible, feedback of information to farmers has been limited, and not regarded as integral to the development of the scheme. Objectives of such schemes are most likely to be achieved where management options are flexible, and where farmers are fully involved in an iterative way in their development. Such a system would permit the integration of political, economic and cultural influences on conservation management.

Understanding farmers' interests through participatory research therefore can contribute to the development of habitat management or multifunctional landuse systems. Wherever it occurs, and whatever the primary reason for initial adoption of management by an individual farmer, subsequent transmission of ideas and behaviour may be determined for quite different cultural or agricultural reasons. One farmer at the Senegambia study site who grew *Fairdherbia albida* saplings from seed and encouraged naturally regenerating plants on his farm to enhance soil fertility, was most enthusiastic about this species when recounting the story of a Muslim prophet who used it to build a boat. Other tree species have different cultural values, especially the association of *Piliostigma* with initiation ceremonies. The use of this and other species for agricultural purposes may be influenced by their cultural values – values that are currently threatened by a global process of cultural homogenisation, following the trend in industialised countries (Tomlinson, 1991). Cultural evolution and diversity may be as important to the maintenance of sustainable management of ecosystems, as genetic evolution and diversity are to the creation of those ecosystems in the first place.

Global economic factors also affect management practices such as the establishment of trees on West African farmland. Increasing world prices for cereals and vegetable oils could encourage more long-term objectives and sustainable management of soils, including the use of trees and shrubs. Alternatively, relatively high crop prices could encourage short-term 'mining' of soil resources as is practised by Mouride farmers in northern Senegal (Reij *et al.*, 1996). Strong land tenure, low land availability, and high fertiliser prices at my Senegambian study site provide the right conditions for long-term management of soils, and development of sustainable methods, including tree establishment.

In England, maintenance of perennial herbaceous vegetation in field boundaries is subject to similar combinations of cultural and agricultural motivation. Results from the questionnaire provide a background for further work into farmers' attitudes to field boundary vegetation and the development of practical management options. A more qualitative approach than was used in this study may provide new information on farmers' motivation. For example, Drake *et al.* (1999) found that farmers' participation in an agri-environment scheme was partially explained by the participation of neighbours and relatives in the same scheme, but as in my survey, farmers in their study claimed that these were very minor influences when completing their questionnaires.

My work identified a clear reluctance amongst farmers to establish strips of perennial herbaceous vegetation in field boundaries, although research has shown that this can have agricultural benefits. A greater emphasis on participatory work with farmers in identifying in more detail the motivation, cultural values and practical management options could enable farmers to establish field boundary vegetation that meets their own requirements as well as those of farmland birds such as whitethroats.

There is therefore a need for further work on some of the topics that form the subject of this thesis (see box). This includes further research into the ecological implications of some game management practices (especially predator control and provision of winter cover and feed). It also includes research into sociological aspects of habitat management on farmland, especially more qualitative research into the influences (including family and other farmers) on farmers' management decisions. Wild game management in Britain and the management of trees and shrubs in Senegambia represent two examples of management that are likely to benefit farmland birds and require further work *with* farmers in order to identify an approach that meets their cultural and agricultural requirements.

Recommendations for continued work

Game management in lowland England

- Participatory work (at level 6 of table 4.1) with farmers and landowners to identify cultural and economic constraints on wider adoption of the wild game management package and its component practices
- Promotion of the cultural value of non-game birds associated with habitats managed for game during the breeding season
- Research into the contribution of seed-bearing gamecrops (and other supplementary feed) to the winter survival of farmland birds and the implications for their local and regional breeding abundance
- Continued research into the impact of predator control on passerine breeding abundance, including cessation of predator control and continued monitoring at the Loddington study site
- Promotion of the cultural values of non-game birds using gamecrops and the promotion of crop mixtures to enhance bird abundance and diversity

Field boundary management in lowland England

- Participatory work with farmers (at level 6 of table 4.1) to identify the cultural and agricultural requirements and constraints relating to field boundary management, and development of appropriate management options.

Trees and shrubs in Senegambia

- Participatory work with farmers (at level 7 of table 4.1) and infrastructure support for environmental improvement on farmland

References

Agnew, C.T. (1995) Desertification, drought and development in the Sahel. In: Binns, T. (ed.) *People and Environment in Africa.* Wiley, Chichester. 137-149.

Agra Europe (1991) *Agriculture and the Environment: how will the EC resolve the conflict?* Agra Europe Special Report No. 60.

Aebischer, N.J. (1991) Sustainable yields: gamebirds as a harvestable resource. *Gibier Faune Sauvage* 8: 335-351.

Aebischer, N.J. (1999) Multi-way comparisons and generalised linear models of nest success: extensions of the Mayfield method. *Bird Study* 46 suppl.: 22-31.

Aebischer, N.J., Green, R.E. & Evans, A.D. (2000) From science to recovery: four case studies of how research has been translated into conservation action in the UK. In: Aebischer, N.J., Evans, A.D., Grice, P.V. & Vickery, J.A, (eds.) *Ecology and Conservation of Lowland Farmland Birds.* British Ornithologists' Union, Tring. 43-54.

Aebischer, N.J. & Ward, R.S. (1997) The distribution of corn buntings *Miliaria calandra* in Sussex in relation to crop type and invertebrate abundance. In: Donald, P.F. & Aebischer, N.J. (eds.) *The ecology and conservation of corn buntings* Miliaria calandra. JNCC, Peterborough. 124-138.

Alerstam, T. (1990) *Bird Migration.* Cambridge University Press, Cambridge.

Andreasen, C., Stryhn, H. & Streibig, J.C. (1996) Decline in the flora in Danish arable fields. *Journal of Applied Ecology* 33: 619-626.

Andrén, H. (1992) Corvid density and nest predation in relation to forest fragmentation: a landscape perspective. *Ecology* 73: 794-804.

Andrews, J. & Rebane, M. (1994) *Farming & Wildlife: A Practical Management Handbook.* RSPB, Sandy. 358 pp.

Anon (1948) *The use of lime in Agriculture*. MAFF Bulletin 35.

Anon (1995) *Biodiversity: The UK Steering Group Report Volume 2. Action Plan.* HMSO, London.

Anon (1999) A better quality of life – a strategy for sustainable development for the United Kingdom. Department of the Environment, Transport and the Regions.

Araújo, M., Borralho, R. & Stoate, C. (1996) Can biodiversity be measured using composite indices? *1 Congresso de Ornithologia.* Sociedade Portuguesa para o Estudo das Aves, Lisbon. 124-125.

Arnold, G.W. (1983) The influence of ditch and hedgerow structure, length of hedgerows, and area of woodland and garden on bird numbers on farmland. *Journal of Applied Ecology* 20: 731-750.

Asuzu, I.U., Gray, A.I. & Waterman, P.G. (1999) The antihelmintic activity of D-3-*O*-methylchiroinositol isolated from *Piliostigma thonningii* stem bark. *Fitoterapia* 70: 77-79.

Attwood, P.J. (1985) *Crop Protection Handbook – Cereals.* BCPC Publications, Croydon.

Aughney, T.C. & Gormally, M.J. (1999) Attitudes of farmers in the west of Ireland to the Rural Environment Protection Scheme. In: Pienkowski, M.W. & Jones, D.G. (eds.) *Managing High-nature-conservation-value Farmland: Policies, Processes* *and Practices*. European Forum on Nature Conservation and Pastoralism. 104-107.

Avery, D. (1995) Preserving wildlife habitat – with agrochemicals. *The Agronomist*, Spring: 10-12.

Ayers, A. (1995) Indigenous soil and water conservation in Djenné, Mali. In: Brokensha, D., Warren, D.M. & Slikkerveer, J. (eds.) *The Cultural Dimension of Development*.

Azjen, I. & Fishbein, M. (1980) Understanding attitudes and predicting social behaviour. Prentice-Hall, Englewood Cliffs, NJ.

Azjen, I. (1985) From intentions to actions: a theory of planned behaviour. In: Kuhle, J. & Beckmann, J. (eds.) *Action-control: From Cognition to Behaviour*. Springer, Heidelberg. 11-39.

Baillie, S.R. & Peach, W.J. (1992) Population limitation in Palaearctic-African migrant passerines. *Ibis* 134 suppl.: 120-132.

Baillie, S.R., Sutherland, W.J., Freeman, S.N., Gregory, R.D. & Paradis, E. (2000) Consequences of large-scale processes for the conservation of bird populations. *Journal of Applied Ecology* **37**, 88-102.

Baines, D. (1988) The effects of improvement of upland, marginal grasslands on the distribution and density of breeding wading birds (Charadriiformes). *Biological Conservation* 45: 221-236.

Baines, D. (1990) The role of predation, food and agricultural practice in determining the breeding success of the lapwing *Vanellus vanellus* and other waders. *Ibis* 131: 497-506.

Bairlein, F. & Simons, D. (1995) Nutritional adaptations in migrating birds. *Israel Journal of Zoology* 41: 357-367.

Baker, S.E. & MacDonald, D.W. (2000) Foxes and foxhunting on farms in Wiltshire: a case study. *Journal of Rural Studies* 16: 185-201.

Barr, C., Gillespie, M. & Howard, D. (1994) Hedgerow Survey 1993: stock and change estimates of hedgerow length in England and Wales, 1990-1993. Institute of Terrestrial Ecology, Grange over Sands.

Battershill, M.R.J. & Gilg, A.W. (1996) Traditional farming and agro-environment policy in southwest England: back to the future? *Geoforum* 27: 133-147.

Battershill, M.R.J. & Gilg, A.W. (1997) Socio-economic constraints and environmentally friendly farming in the southwest of England. *Journal of Rural Studies* 13: 213-228.

Battershill, M.R.J. & Gilg, A.W. (1998) Traditional low intensity farming: evidence of the role of *vente directe* in supporting such farms in north west France, and some implications for conservation policy. *Journal of Rural studies* 14: 475-486.

Bealey, C., Green, R.E., Robson, R., Taylor, C.R. & Winspear, R. (1999) Factors affecting the numbers and breeding success of Stone Curlews *Burhinus oedicnemus* at Porton Down, Wiltshire. *Bird Study* 46: 145-156.

Bednekoff, P.A. & Houston, A.I. (1994) Optimizing fat reserves over the entire winter: a dynamic model. *Oikos* 71: 408-415.

Beedell, J.D.C. & Rehman, T. (1996) Farmers' perceptions of conservation and the provision of advice on the management of the countryside. *Agricultural Progress* 71: 29-35.

Beedell, J. & Rehman, T. (1999) Explaining farmers' conservation behaviour: why do farmers behave the way they do? *Journal of Environmental Management* 57: 165-176.

Beedell, J. & Rehman, T. (2000) Using social-psychology models to understand farmers' conservation behaviour. *Journal of Rural Studies* 16: 117-127.

Beintema, A.J., Dunn, E. & Stroud, D.A. (1997) Birds and wet grasslands. In: Pain, D. & Pienkowski, M.W. (eds.) *Farming and Birds in Europe*. 117-149. Academic Press, London.

Bence, S., Stander, K. & Griffiths, M. (1999) Nest site selection by the harvest mouse (*Micromys minutus*) on arable farmland. *Aspects of Applied Biology* 54: 197-202.

Benneh, G. (1996) *Towards Sustainable Smallholder Agriculture in Sub-Saharan Africa.* International Food Policy Research Institute, Washington.

Benoit, F., Valentin, A., Pelissier, Y., Diafouka, F., Marion, C., Kone-Bamba, D., Kone, M., Mallie, M., Yapo, A. & Bastide, J-M. (1996) In vitro antimalarial activity of vegetal extracts used in West African traditional medicine. *American Journal of Tropical Medicine and Hygiene* 54: 67-71.

Berthold, P. & Helbig, A. (1992) The genetics of bird migration: stimulus, timing and direction. *Ibis* 134: 35-40.

Biber O. (1993) [Availability and use of hedges and shrubs as nest sites by yellowhammers *Emberiza citrinella* in an area of intensive agriculture in Switzerland] *Der Ornithologische Beobachter* 90: 115-132.

Boatman, N.D. (1989) Selective weed control in field margins. Brighton Crop Protection Conference – Weeds 2: 785-794.

Boatman N D, Blake K A, Aebischer N J & Sotherton N W. (1992) Factors affecting the herbaceous flora of hedgerows on arable farms and its value as wildlife habitat. In: Watt, T.A. & Buckley, G.P. (eds.) *Hedgerow Management and Nature Conservation*. British Ecological Society, Conservation Ecology Group. 33-46.

Boatman, N.D., Rew, L.J., Theaker, A.J. & Froud-Williams, R.J. (1994) The impact of nitrogen fertiliser on field margin flora. In: Boatman, N.D. (ed.) *Field Margins: integrating agriculture and conservation*. BCPC Monograph 58: 209-214.

Boatman, N.D. & Brockless, M.H. (1998) The Allerton Project: Farmland management for partridges (*Perdix perdix, Alectoris rufa*) and pheasants (*Phasianus colchicus*). *Gibier Faune Sauvage* **15**: 563-574.

Boatman, N.D., Stoate, C. & Watts, N. (2000) Practical management solutions for birds on lowland arable farmland. In: Aebischer, N.J., Evans, A.D., Grice, P.V. & Vickery, J.A. (eds.) *Ecology and Conservation of Lowland Farmland Birds*. British Ornithologists' Union, Tring. 105-114.

Böhning-Gaese, K., Taper, M.L. & Brown, J.H. (1993) Are declines in North American insectivorous songbirds due to causes on the breeding grounds? *Conservation Biology* 7: 76-86.

Boserup, E. (1965) *The Conditions of Agricultural Growth*. Earthscan, London.

Bouwman, A.F. (1990) The effect of changing land cover on the surface energy balance. In: Bouwman, A.F. (ed.) *Soils and the Greenhouse* Effect. Wiley, Chichester. 143-152.

Bradbury, R.B. & Stoate, C. (2000) The ecology of yellowhammers *Emberiza citrinella* on lowland farmland. In: Aebischer, N.J., Evans, A.D., Grice, P.V. & Vickery, J.A. (eds.) Ecology and Conservation of Lowland Farmland Birds. British Ornithologists' Union, Tring. 165-172.

Braun, J.V., Johm, K., Kinteh, S. & Puetz, D. (1990) *Structural Adjustment, Agriculture, and Nutrition: Policy Options in The Gambia*. International Food policy Research Institute, Washington.

Brickle, N. (1998) *The effect of agricultural intensification on the decline of the corn bunting* Miliaria calandra. Unpublished PhD thesis. University of Sussex, Brighton.

Brickle, N. & Harper, D. (2000) The ecology of corn buntings *Miliaria calandra* on lowland farmland. Aebischer, N.J., Evans. A.D., Grice, P.V. & Vickery, J.A. (eds.) *Ecology and Conservation of Lowland Farmland Birds.* British Ornithologists' Union, Tring. 156-164.

Brooks, D., Bater, J., Jones, H. & Shah, P.A. (1995) *Invertebrate food sources for birds in organic and conventional farming systems. Part IV. The effect of organic farming regimes on breeding and winter bird populations.* BTO Research Report 154. British Trust for Ornithology, Thetford.

Brown, R.W. (1999) Margin/field interfaces and small mammals. *Aspects of Applied Biology* 54: 203-206.

Browne, S., Vickery, J. & Chamberlain, D. (2000) Densities and population estimates of breeding skylarks *Alauda arvensis* in Britain in 1997. *Bird Study* 52-65.

Buckingham, D.L., Evans, A.D., Morris, A.J., Yaxley, A. & Parsons, M. (2000) *Use of set-aside land during the breeding season by declining farmland bird species in the UK.* BTO, Tring.

Buckland, S.T., Anderson, D.R., Burnham, K.P. & Laake, J.L. (1993) *Distance Sampling*. Chapman & Hall, London.

Burel, F., Baudry, J., Buter, A., Clergeau, P., Delettre, Y., Le Couer, D., Dubs, F., Morvan, N., Paillat, G., Petit, S., Thenail, C., Brunel, E. & Lefeuvre, J-C. (1998) Comparative biodiversity along a gradient of agricultural landscapes. *Acta Oceologica* 19: 47-60.

Burgess, J., Clark, J. & Harrison, M. (2000) Knowledges in action: an actor network analysis of a wetland agri-environment scheme. *Ecological Economics* 35: 119-132.

Burton, N.H.K., Watts, P., Crick, H.Q.P. & Edwards, J. (1999) The effects of pre-harvesting operations on reed buntings *Emberiza schoeniclus* nesting in oilseed rape *Brassica napus*. *Bird Study* 46: 369-372.

Busse, P. (1992) Migratory behaviour of blackcaps (*Sylvia atricapilla*) wintering in Britain and ireland: contradictory hypotheses. *Ring* 14: 51-75.

Busse, P., Baumanis, J., Leivits, A., Pakkala, H., Payevsky, V.A. & Ojanen, M. (1995) Population number dynamics 1961-1990 of *Sylvia* species caught during migration at some north and central European bird station. *The Ring* 17: 11-30.

Carr, S. & Tait, J. (1990) Farmers' attitudes to conservation. *Built Environment* 16 (3): 218-231.

Carr, S. & Tait, J. (1991) Differences in the attitudes of farmers and conservationists and their implications. *Journal of Environmental Management* 32: 281-294.

Carson, R. (1962) *Silent Spring*. Houghton Mifflin, Boston.

Campbell,L.H., Avery,M., Donald,P.F., Evans,A.D., Green,R.E. & Wilson,J.D. (1997) *A review of the indirect effects of pesticides on birds.* JNCC, Peterborough.

Cantos, F.J. & Telleria, J.L. (1994) Stopover site fidelity of four migrant warblers in the Iberian Peninsula. *Journal of Avian Biology* 25: 131-134.

Chambers, R. (1997) *Whose Reality Counts?* Intermediate Technology, London.

Chamberlain, D.E., Hatchwell, B.J. and Perrins, C.M. (1995) Spaced out nests and predators: an experiment to test the effects of habitat structure. *Journal of Avian Biology* 26 (4):346-349.

Chamberlain, D.E., Wilson, J.D., Browne, S.J. & Vickery, J.A. (1999) Effects of habitat type and management on the abundance of Skylarks in the breeding season. *Journal of Applied Ecology* 36: 856-870.

Chaney, K., Evans, S.A. & Wilcox, A. (1997) Effect of cropping practice on skylark distribution and abundance. *Brighton Crop Protection Conference: Weeds.* Brighton:1173-1178.

Chaney, K., Wilcox, A., Perry, N.H. & Boatmen, N.D. (1999) The economics of establishing field margins and buffer zones of different widths in cereal fields. *Aspects of Applied Biology* 54: 79-84.

Cheikh, A.W.O. (1990) Mauritania: Nomadism and peripheral capital. In: Amara, H.A. & Founou-Tchiugoua, B. (eds.) *African Agriculture: The Critical Choices.* Zed, London. 68-99.

Cissé, M.I. & Koné, A.R. (1992) The fodder role of *Acacia albida* Del.: extent of knowledge and prospects for future research. In: Vandenbelt, R.J. (ed.) Faidherbia albida *in the West African semi-arid tropics: proceedings of a workshop*, 22-26 April 1991, Niamey, Niger. 29-37.

Cooke, A.S., Bell, A.A., Haas, M.B. (1982) *Predatory Birds, Pesticides and Pollution.* ITE, Merlewood.

Cooper, A.B., Ngapo, N.I., Parminter, T.G. & Stroud, M.J. (1997) Encouraging implementation of riparian buffer schemes – the New Zealand experience. In: Haycock, N.E. & Burt, T.P. (eds.) *Buffer Zones: Their Processes and Potential in Water Protection.* Quest Environmental, Harpenden.295-304.

Coppock, J.T. (1971) *An Agricultural Geography of Great Britain.* Bell, London.

Côté, I.M. & Sutherland, W.J. (1996) The effectiveness of removing predators to protect bird populations. *Conservation Biology* 11: 395-405.

Countryside Commission (1997) *Public Attitudes to the Countryside.* Countryside Commission, Cheltenham.

Cowgill, S.E., Wratten, S.D. & Sotherton, N.W. (1993) The selective use of floral resources by the hoverfly *Episyrphus balteatus* (Diptera: Syrphidae) on farmland. *Annals of Applied Biology* 122: 223-231.

CPRE (1999) Meadow Madness: why the loss of England's grasslands continues uncontested. Council for Protection of Rural England, London.

Cramp, S. & Perrins, C.M. (1994) *Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of the Western Palearctic. Vol. IX Buntings and New World Warblers.* Oxford University Press.

Cramp, S. & Brooks, D.J. (1992) *Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of the Western Palearctic. Vol. VI Warblers.* Oxford University Press.

Crane, D. (1994) *The Sociology of Culture*. Blackwell, Oxford.

Cresswell, W. (1997) Nest predation: the relative effects of nest characteristics, clutch size and parental behaviour. *Animal Behaviour* 53: 93-103.

Crick, H.Q.P., Dudley, C., Evans, A.D. & Smith, K.W. (1994) Causes of nest failure among buntings in the UK. *Bird Study* 41:88-94

Crick H.Q.P., Baillie, S.R., Balmer, D.E., Bashford, R.I., Dudley, C., Glue, D.E., Gregory, R.D., Marchant, J.H., Peach, W.J. & Wilson, A.M. (1997) *Breeding Birds in the Wider Countryside: their conservation status (1971-1995).* British Trust for Ornithology, Thetford.

Cuadrado, M., Senar, J.C. & Copete, J.L. (1995) Do all Blackcaps *Sylvia atricapilla* show winter site fidelity? *Ibis* 137: 70-75.

Cussans, G.W. & Marshall, E.J.P. (1990) Weed ecology and management. *IACR Report* 1990.

Cuthbertson, P.S. & Jepson, P.C. (1988) Reducing pesticide drift into the hedgerow by the inclusion of an unsprayed field margin. In: Brighton Crop Protection Conference – *Pests and Diseases.* British Crop Protection Council. 747-751.

Davies, N.B. & Lundberg, A. (1984) Food distribution and a variable mating system in the dunnock *Prunella modularis. Journal of Animal Ecology* 54: 895-912.

Dawkins, R. (1976) *The Selfish Gene.* Oxford University Press, Oxford.

Desowitz, R.S. (1980) Epidemiological-ecological interactions in savanna environments. In: Harris, D.R. (ed.) *Human Ecology in Savanna Environments.* Academic Press, London. 457-477.

Diack, M. (1998) Piliostigma reticulatum *dans un Parc a Cordyla pinnata. Effet sur la Regeneration des Sols Degrades au Sénégal.* République du Sénégal, Ministère de l'Agriculture.

Diener, P. & Robkin, E.E. (1978) Ecology, evolution, and the search for cultural origins: the question of Islamic pig prohibition. *Current Anthropology* 19: 493-540.

Dhondt, A.A., Kempenaers, B. & clobert, J. (1998) Sparrowhawk *Accipiter nisus* predation and Blue Tit *Parus caeruleus* adult survival rate. *Ibis* 140: 580-584.

Donald, P. (1997) The corn bunting *Miliaria calandra* in Britain: a review of current status, patterns of decline and possible causes. In: Donald, P. & Aebischer, N.J. (eds.) *The ecology and conservation of corn buntings* Miliaria calandra. JNCC, Peterborough.

Donald, P. & Evans, A.D. (1994) Habitat selection by corn buntings *Miliaria calandra* in Britain. *Bird Study* 41: 199-210.

Douglas, M. (1996) *Thought Styles: Critical Essays on Good Taste.* Sage, London.

Dover, J. (1996) Factors affecting the distribution of satyrid butterflies on arable farmland. *Journal of Applied Ecology* 33: 723-734.

Dover, J. (1999) Butterflies and field margins. *Aspects of Applied Biology* 54: 117-124.

Dowsett, R.J., Buckhurst, G.C. & Oatby, T.B. (1988) Afrotropical ringing recoveries of Palaearctic migrants. 1. Passerines (Turdidae to Oriolidae). *Tauraco* 1: 29-63.

directions in pastoral development in Africa. Intermediate Technology, London. 37-46.

Ellis, N.E., Heal, O.W., Dent, J.B. & Firbank, L.G. (1999) Pluriactivity, farm household socio-economics and the botanical characteristics of grass fields in the Grampian region of Scotland. *Agriculture, Ecosystems and Environment* 76: 121-134.

Entec (1995) *Effects of Organic Farming on the Landscape*. Countryside Commission, Cheltenham.

Environment Agency (1999) *Sustainable Water Resources for the Future: Values and Challenges*. Environment Agency, Bristol. 16pp.

Evans, P.R. (1969) Winter fat deposition and overnight survival of yellow buntings (*Emberiza citrinella*). *Journal of Animal Ecology* 38: 415-423.

Evans, A.D. & Smith, K.W. (1994) Habitat selection of cirl buntings Emberiza cirlus wintering in Britain. *Bird Study* 41: 81-87.

Evans, A.D. (1997) Seed-eaters, stubble fields and set-aside. *Brighton Crop Protection Conference – Weeds*. BCPC, Brighton. 907-914.

Evans, A.D., Smith, K.W., Buckingham, D.L. & Evans, J. (1997) Seasonal variation in breeding performance and nestling diet of cirl buntings *Emberiza cirlus* in England. *Bird Study* 44: 66-79.

Ewald, J. & Aebischer, N.J. (1999) *Pesticide use, avian food resources and bird densities in Sussex*. JNCC Report No. 296.

Falconer, J. (1999) Non-timber forest products in southern Ghana: traditional and cultural forest values. In: Posey, D.A. (ed.) *Cultural and Spiritual Values of Biodiversity*.

Dunn, E. (1977) Predation by weasels (Mustela nivalis) on breeding tits (Parus spp.) in relation to the density of tits and rodents. *Journal of Animal Ecology* 46: 633-652.

Dupuy, N. & Dreyfus, B. (1992) Presence of *Bradyrhizobia* under *Acacia albida*. In: Vandenbelt, R.J. (ed.) Faidherbia albida *in the West African semi-arid tropics: proceedings of a workshop*, 22-26 April 1991, Niamey, Niger. 145-148.

Drake, L., Bergström, P. & Svedsäter, H. (1999) Farmers' attitudes to and uptake of Countryside Stewardship Policies. In: Van Huylenbroeck, G. (ed.) *Research Project in the Framework of the EU-Fair Programme Market Effects of Countryside Stewardship Policies*. University of Gent. 1-22.

Drummond, C.J. (2000) Environmental management systems in practice: The experiences of LERAF (Linking Environment And Farming) in meeting the needs of farmers, consumers and environmentalists. *Aspects of Applied Biology* 62: 165-172.

Eder, K. (1996) *The Social Construction of Nature*. Sage, London.

Edwards, C.A. & Lofty, J.R. (1977) *The Biology of Earthworms*. Chapman and Hall, London.

Elligsen, H., Beinlich, B. & Plachter, H. (1997) Effects of large-scale cattle grazing on populations of *Coenonympha glycerion* and *Lasiommata megera* (Lepidoptera: Satyridae). *Journal of Insect Conservation* 1: 13-23.

Elliot, R.H. (1898) *The Clifton Park System of Farming and Laying Land Down to Grass*. Faber & Faber, London.

Ellis, J. (1994) Climate variability and complex ecosystem dynamics: implications for pastoral development. In: Scoones, I. (ed.) *Living With Uncertainty: New*

United Nations Environment Programme/ Intermediate Technology Publications, London. 366-370.

Fretwell, S.D. & Lucas, J.H.L. (1970) On territorial behaviour and other factors influencing habitat distribution in birds. *Acta Biotheoretica* 19: 16-36.

Fuller, R.M. (1987) The changing extent and conservation interest of lowland grassland in England and Wales: a review of grassland surveys. *Biological Conservation* 40: 281-300.

Fuller, R.J., Gregory, R.D., Gibbons, D.W., Marchant, J.H., Wilson, J.D., Baillie, S.R. & Carter, N. (1995) Population declines and range contractions among lowland farmland birds in Britain. *Conservation Biology* 9: 1425-1441.

Furness, R.W. & Greenwood, J.J.D. (1993) *Birds as Monitors of Environmental Change.* Chapman & Hall, London.

Galbraith, H. (1988) Effects of agriculture on the breeding ecology of lapwings *Vanellus vanellus. Journal of Applied Ecology* 25: 487-503.

Gardner, B. (1996) *European Agriculture: policies, production and trade.* Routledge, London.

Gasson, R. & Potter, C. (1988) Conservation through land dispersion: a survey of farmers' attitudes. *Journal of Agricultural Economics* 39: 340-351.

Giampietro, M. (1997) Socio-economic pressure, demographic pressure, environmental loading and technological changes in agriculture. *Agriculture, Ecosystems and Environment* 65: 201-229.

Gibbons, D.W., Reid, J.B. & Chapman, R.A. (1993) *The New Atlas of Breeding Birds in Britain and Ireland*: 1988-1991. Poyser, London.

Gillings, S. & Fuller, R.J. (1998) Changes in bird populations on sample lowland English farms in relation to loss of hedgerows and other non-crop habitats. *Oecologia* **116**: 120-127.

Gleeve, M.B. (1996) The length of the fallow period in tropical fallow farming systems: a discussion with evidence from Sierra Leone. *The Geographical Journal* 162, 14-24.

Glück, E. (1986) Flock size and habitat dependent food and energy intake of foraging goldfinches. *Oecologia* 71: 149-155.

Gooch, S., Baillie, S.R. & Birkhead, T.R. (1991) Magpie *Pica pica* and songbird populations: retrospective investigation of trends in population density and breeding success. *Journal of Applied Ecology* 28: 1068-1086.

Gosler, A.G., Greenwood, J.D. & Perrins, C. (1995) Predation risk and the cost of being fat. *Nature* 377: 621-623.

Götmark, F., Blomqvist, D., Johansson, O.C. & bergkvist, J. (1995) Nest site selection: a trade-off between concealment and view of the surroundings? *Journal of Avian Biology* 26: 305-312.

Green, B.H. (1990) Agricultural intensification and the loss of habitat, species and amenity in British grasslands: a review of historical change and assessment of future prospects. *Grass and Forage Science* 45: 365-372.

Green, R.E. (1996) Factors affecting the population density of the Corncrake *Crex crex* in Britain and Ireland. *Journal of Applied Ecology* 33: 237-248.

Green, R.E. & Williams, G. (1997) The ecology of the corncrake Crex crex and action for its conservation in Britain and Ireland. In: Bignal, E.M., McCracken, D.I. &

Curtis, D.J. (eds.) *Nature Conservation and Pastoralism in Europe*. Joint Nature Conservancy Committee, Peterborough. 69-74.

Green, R.E., Osborne, P.E. & Sears, E.J. (1994) The distribution of passerine birds in hedgerows during the breeding season in relation to characteristics of the hedgerow and adjacent landscape. *Journal of Applied Ecology* 31: 677-692.

Greenberg, R. (1995) Insectivorous migratory birds in tropical ecosystems: the breeding currency hypothesis. *Journal of Avian Biology* 26: 260-264.

Greenwood, J.D. & Baillie, S.R. (1991) Effects of density-dependence and weather on population changes of English passerines using a non-experimental paradigm. *Ibis* 133: 121-133.

Gregory, R.D., Noble, D.G., Campbell, L.H. & Gibbons, D. (2000) *The State of the UK's Birds 1999*. RSPB and BTO, Sandy.

Gregory, R.D. & Marchant, J.H. (1996) Population trends of jays, magpies, jackdaws and carrion crows in the United Kingdom. *Bird Study* 43, 28-37.

Grigg, D. (1989) *English Agriculture: An Historical Perspective*. Blackwell, Oxford.

Groom, D.W. (1993) Magpie *Pica pica* predation on Blackbird *Turdus merula* nests in urban areas. *Bird Study* 40, 55-62.

Grubb, T.C. & Cimprich, D.A. (1990) Supplementary food improves the nutritional condition of wintering woodland birds: evidence from ptilochronology. *Ornis Scandinavica* 21: 277-281.

Haines-Young, R.H. Barr, C.J., Black, H.I.J., Briggs, D.J., Bunce, R.G.H., Clarke, R.T., Cooper, A., Dawson, F.H., Firbank, L.G., Fuller, R.M., Furse, M.T., Gillespie, M.K., Hill, R., Hornung, M., Howard, D.C., McCann, T., Morecroft, D., Petit, S., Sier, A.R.J., Smart, S.M., Smith, G.M., Stott, A.P., Stuart, R.C. and Watkins, J.W. (2000) *Accounting for nature: assessing habitats in the UK countryside*, DETR, London.

Hanley, J.A. (ed.) (1949) *Progressive Farming, the Maintenance of High Produc*tion. Caxton, London.

Harris, S. and Woollard, T. (1990) The dispersal of mammals in agricultural habitats in Britain. In: Bunce, R.G.H. & Howard, D.C. *Species Dispersal in Agricultural Habitats*. Belhaven Press, London. 159-188.

Harrison, C.M., Burgess, J. & Clark, J. (1998) Discounted knowledges: farmers' and residents' understandings of nature conservation goals and policies. *Journal of Environmental Management* 54: 305-320.

Hart, K. (1982) *The Political Economy of West African Agriculture*. Cambridge University Press.

Haughton, A.J. Wilcox, A., Chaney, K. & Boatman, N.D. (1999) The effects of different rates of glyphosate on non-target invertebrates in field margins. *Aspects of Applied Biology* 54: 185-190.

Henderson, I.G., Vickery, J.A. & Fuller, R.J. (2000) Summer bird abundance and distribution of birds on set-aside fields on intensive arable farms in England. *Ecography* 23: 50-59.

Hervouët, J.P. (1992) *Faidherbia albida*: a witness of agrarian transformation. In: Vandenbelt, R.J. (ed.) Faidherbia albida *in the West African semi-arid tropics: proceedings of a workshop*, 22-26 April 1991, Niamey, Niger. 165-169.

Higginbotham, S., Leake, A.R., Jordan, V.W. & Ogilvy, S.E. (2000) Environmental and ecological aspects of integrated, organic and conventional farming systems. *Aspects of Applied Biology* 62: 15-20.

Högstad, O. (1993) Nest defence and physical condition in Fieldfare *Turdus pilaris. J. Orn.* 134: 25-33.

Holloway, S. (1996) *The historical atlas of breeding birds in Britain and Ireland: 1875-1900.* Poyser, London.

Holyoak, D.T. (1993) A comparative study of the food of some British Corvidae. *Bird Study* **15**, 147-154.

Hopkins, A.G. (1990) *An Economic History of West Africa.* Longman, Harlow.

Houston, A.I. & McNamara, J.M. (1993) A theoretical investigation of the fat reserves and mortality levels of small birds in winter. *Ornis Scandinavica* 24: 205-219.

Howlett, J.S. & Stutchbury, B.J. (1996) Nest concealment and predation in hooded warblers: experimental removal of nest cover. *The Auk* 113 (1):1-9.

Hudson, R. Tucker, G.M. & Fuller, R.J. (1994) Lapwing *Vanellus vanellus* populations in relation to agricultural changes: a review. In: Tucker, G.M., Davies, S.M. & Fuller, R.J. (eds.) *The ecology and conservation of lapwings* Vanellus vanellus. JNCC, Peterborough. 1-26.

Hyden, G., Kates, R.W. & Turner, B.L. (1993) Beyond intensification. In: Turner, B.L., hyden, G. & Kates, W. (eds.) *Population Growth and Agricultural Change in Africa.* University press of Florida, Gainsville. 401-439.

Ibewuike, J.C., Ogungbamila, F.O., Ogundaini, A.O., Okeke, I.N. & Bohlin, L. (1997) *Phytotherapy Research* 11: 281-281.

Ingerson, A.I. (1994) Tracking and testing the nature-culture dichotomy. In: Crumley, C.L. (ed.) *Historical Ecology: Cultural Knowledge and Changing Landscapes*. School of American Research Press, Sante Fe.

Ilbery, B. (1991) Farm diversification as an adjustment strategy on the urban fringe of the West Midlands. *Journal of Rural Studies* 7: 207-218.

Iwu, M.M. (1999) Symbols and selectivity in traditional African medicine. In: Posey, D.A. (ed.) *Cultural and Spiritual Values of Biodiversity*. United Nations Environment Programme/ Intermediate Technology Publications, London. 282-284.

Izzi Dien, M. (2000) *The Environmental Dimensions of Islam*. Lutterworth, Cambridge.

Jenny, M., Lugrin, B., Weibel, U., Regamey, J-L & Zbinden, N. (1997) *Der ökologische Ausgleich in intensiv genutzten Ackerbaugebieten der Champagne genevoise GE und des Klettgaus SH und seine Bedeutung für Vögel, Pflanzen und ausgewählte Wirbellose*. BUWAL.

Jones, P., Vickery, J., Holt, S. & Cresswell, W. (1996) A preliminary assessment of some factors influencing the density and distribution of Palearctic passerine migrants wintering in the Sahel zone of West Africa. *Bird Study* 43: 73-84.

Kannan, R. (1991) Organochlorine pesticide concentrations in various species of migratory passerines in Louisiana. *Proceedings Arkansas Academy of Science* 45: 46-47.

Kane, S., Ba, B. & Sow, P. (1990) The state and rural development 1960-85. In: Amara, H.A. & Founou-Tchiugoua, B. (eds.) *African Agriculture: The Critical Choices*. Zed, London. 170-191.

Kazenwadel, G., van der Ploeg, B., Baudoux, P. & Häring, G. (1998) Sociological and economic factors influencing farmers' participation in agri-environment schemes. In: Dabbert, S., Dubgaard, A., Slangen, L. & Whitby, M. (eds.) *The Economics of Landscape and Wildlife Conservation*. CAB International.

Kirkham, F.W., Tallowin, J.R.B. & Wilkins, R.J. (1992) *The Effects of Nitrogen on Species Diversity and Agricultural Production on the Somerset Levels*. Agricultural and Food Research Council.

Krebs, J.R. (1971) Territory and breeding density in the great tit *Parus major* L. *Ecology* 52: 2-22.

Kromp, B. & Steinberger, K.H. (1992) Grassy field margins and arthropod diversity: a case study on ground beetles and spiders in eastern Austria (Coleoptera: Carabidae; Arachnidae: Aranei, Opiliones). *Agriculture, Ecosystems and Environment* 40: 71-93.

Kyrkos A. (1997) *Behavioural and demographic responses of yellowhammers to variation in agricultural practices*. Unpublished PhD thesis. Oxford.

Kyrkos, A., Wilson, J.D. & Fuller, R.J. (1998) Farmland habitat change and abundance of Yellowhammers *Emberiza citrinella*: an analysis of Common Birds Census data. *Bird Study* 45: 232-246.

Laake, J.L., Buckland, S.T., Anderson, D.R. & Burnham, K.P. (1993) *DISTANCE User's Guide. Version 2.0*. Colorado Co-operative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, USA.

Lack, P. (1987) The effects of severe hedge cutting on a breeding bird population. *Bird Study* 34: 139-146.

Lack, P. (1988) Hedge intersections and breeding bird distribution in farmland. *Bird Study* 35: 133-136.

Lack, P. (1992) *Birds on Lowland Farms*. HMSO, London.

Laird, S.A. (1999) Forests, culture and conservation. In: Posey, D.A. (ed.) *Cultural and Spiritual Values of Biodiversity*. United Nations Environment Programme/ Intermediate Technology Publications, London. 347-362.

Lal, R. (1996) Tropical deforestation and its impact on soil environment and agricultural productivity. In: Benneh, G., Morgan, W.B. & Uitto, J.I. (eds.) *Sustaining the Future: Economic, social, and environmental change in Sub-Saharan Africa.* United Nations University Press, Tokyo.

Leisler, B. (1992) Habitat selection and coexistence of migrants and Afrotropical residents. *Ibis* 134: 77-82.

Levin, R. (1970) Extinctions. *Lect. Math. Life Sci.* 2: 75-107.

Lima, S.L., Wiebe, K.L. & dill, L.M. (1987) Protective cover and the use of space by finches: is closer better? *Oikos* 50: 225-230.

Lima, S.L. & Valone, T.J. (1991) Predators and avian community organisation: an experiment in a semi-desert grassland. *Oecologia* 86: 105-112.

Lindström, A., Daan, S. & Visser, G.H. (1994) The conflict between moult and migratory fat deposition: a photoperiodic experiment with bluethroats. *Anim. Bahav.* 48: 1173-1181.

Lobley, M. & Potter, C. (1998) Environmental Stewardship in UK Agriculture: A Comparison of the Environmentally Sensitive Area Programme and the Countryside Stewardship Scheme in South East England. *Geoforum* 29: 413-432.

Lock, L. (1999) Saving the Cirl Bunting … and lots more. *British Wildlife* 11:17-21.

Longley, M., Cigli, T., Jepson., P.C. & Sotherton, N.W. (1997) Measurements of pesticide drift deposition into field boundaries and hedgerows. 1. Summer applications. *Environ. Toxicol. Contam.* 16: 165-172.

Lowe, P., Clark, J., Seymour, S & Ward, N. (1997) *Moralizing the Environment.* UCL Press, London.

Lykke, A.M. (1996) *Structure, Floristic Composition, and Dynamics of Woody Savanna Vegetation – Studies from Fathala Forest in Delta du Saloum National Park, Senegal.* Unpublished PhD Thesis, University of Aarhus, Denmark.

Lynne, G.D., Casey, C.F., Hodges, A. & Rahmani, M. (1995) Conservation technology adoption decisions and the theory of planned behaviour. *Journal of Economic Psychology* 16: 581-598.

MacDonald, D.W. (1984) *A questionnaire survey of farmers' opinions and actions towards wildlife.* In: Jenkins, D. (ed.) Agriculture and the Environment. Institute of Terrestrial Ecology, Cambridge. 171-177.

MacDonald, D.W. & Johnson, P.J. (1995) The relationship between bird distribution and the botanical and structural characteristics of hedges. Journal of Applied Ecology 32: 492-505.

Macdonald, D.W. & Johnson, P.J. (2000) Farmers and the custody of the countryside: trends in loss and conservation of non-productive habitats 1981-1998. *Biological Conservation* 94: 221-234.

Macnaghten, P. & Urry, J. (1998) *Contested Cultures.* Sage, London.

Madeley, J. (1996) *Trade and the Poor.* Intermediate Technology, London.

MAFF (1999) *Local Environmental Risk Assessments For Pesticides: A Practical Guide.* Ministry of Agriculture, Fisheries and Food, London.

MAFF (2000) *Towards sustainable agriculture: a pilot set of indicators.* Ministy of Agriculture, Fisheries and Food, London. 72pp.

Maffi, L. (1999) Linguistic diversity. In: Posey, D.A. (ed.) *Cultural and Spiritual Values of Biodiversity.* United Nations Environment Programme/ Intermediate Technology Publications, London. 21-35.

Magurran, A.E. (1988) *Ecological Diversity and its Measurement.* Chapman & Hall, London.

Mandibaya, W. & Chihora, R.M. (1999) The nutritional value of Piliostigma thonningii (Mutukutu, Monkey bread) pods as a feed supplement for communal cattle in Zimbabwe. *Animal Feed Science and Technology* 78: 287-295.

Manly, B.F.J. (1994) *Multivariate Statistical Methods.* Chapman & Hall, London.

Mann, R.D. (1975) *The Gambia: Land and Vegetation Degradation Survey: The need for land reclamation by comprehensive ecological methods.* Unpublished report. Department of Agriculture, Yundum Expt. Stn.

Marchant, J.H. (1992) Recent trends in breeding populations of some common trans-Saharan migrant birds in northern Europe. *Ibis* 134 suppl.: 113-119.

Marchant, J.H., Hudson, R., Carter, S.P. & Whittington, P. (1990) *Population Trends in British Birds.* British Trust for Ornithology, Tring.

Marshall, E.J.P. & Smith, B.D. (1987) Field margin flora: interactions with agriculture. In: Way, J.M. & Grieg-Smith, P.W. (eds.) *Field Margins.* BCPC Monograph 35. British Crop Protection Council. 23-33.

Martin, T.E. (1988) Nest predation and nest site selection of a western population of the hermit thrush. *The Condor* 90: 51-57.

Martin, T.E. (1993) Nest predation among vegetation layers and habitat types: revising the dogmas. *The American Naturalist* 141: 897-913.

Martin, T.E. (1995) Avian life history evolution in relation to nest sites, nest predation and food. *Ecological Monographs* 65: 101-127.

Maudsley, M.J. (2000) A review of the ecology and conservation of hedgerow invertebrates in Britain. *Journal of Environmental Management* 60: 65-76.

Maydell, H-J. von. (1990) *Trees and Shrubs of the Sahel: Their characteristics and uses.* Josef Margraf, Weikersheim.

Mayer-Gross, H., Crick, H.Q.P. & Greenwood, J.J.D. (1997) The effect of observers visiting the nests of passerines: an experimental study. *Bird Study* **44**, 53-65.

Mayfield, H. (1975) Suggestions for calculating nest success. *Wilson Bull.* **87**: 456-466.

McCanch, N. (2000) The relationship between Red-Billed Chough *Pyrrhocorrax pyrrhocorax* (L) breeding populations and grazing pressure on the Calf of Man. *Bird Study* 47: 295-303.

McCleery, R.H., Clobert, J., Julliard, R. & Perrins, C.M. (1996) Nest predation and delayed cost of reproduction in the great tit. *Journal of Animal Ecology* 65: 96-104.

McCracken, D.I., Bignal, E. & Wenlock, S.E. (1995) *Farming on the Edge: the nature of traditional farmland in Europe.* JNCC, Peterborough.

McCulloch, M.N., Tucker, G.M. & Baillie, S.R. (1992) The hunting of migratory birds in Europe: a ringing recovery analysis. *Ibis* 134 suppl.: 55-65.

McGahuey, M. (1992) Extension of *Acacia albida*: recapitalization of the natural resource base. In: Vandenbelt, R.J. (ed.) Faidherbia albida *in the West African semi-arid tropics: proceedings of a workshop*, 22-26 April 1991, Niamey, Niger. 159-164.

McHenry, H. (1998) Wild flowers in the wrong field are weeds: examining farmers' constructions of conservation. *Environment and Planning* 30: 1039-1053.

McNamara, J.M., Houston, A.I. & lima, S.L. (1994) Foraging routines of small birds in winter: a theoretical investigation. *Journal of Avian Biology* 25: 287-302.

Meeus, J.H.A. (1993) The transformation of agricultural landscapes in Western Europe. *The Science of the Total Environment* 129, 171-190.

Metcalfe, N.B. (1984) The effects of habitat on the vigilance of shorebirds: is visibility important? *Animal Behaviour* 32: 981-985.

Middleton, N.J. (1985) *Desertification and Wind Erosion in the Western Sahel: The Example of Mauritania*. School of Geography, University of Oxford. 26pp.

Mitchell, D. (1995) There's no such thing as culture: towards a reconceptualization of the idea of culture in geography. *Transactions of the Institute of British Geographers* 20: 102-116.

Moorcroft, D., Bradbury, R.B. & Wilson, J.D. (1997) The diet of nestling linnets *Carduelis cannabina* before and after agricultural intensification. *Brighton Crop Protection Conference – Weeds*. BCPC, Brighton.

Moorcroft, D. & Wilson, J.D. (2000) The ecology of linnets *Carduelis cannabina* on lowland farmland. In: Aebischer, N.J., Evans, A.D., Grice, P.V. & Vickery, J.A.

(eds.) *Ecology and Conservation of Lowland Farmland Birds*. BOU, Tring. 173-181.

Moore, F.R. & Yong, W. (1991) Evidence of food-based competition among passerine migrants during stopover. *Behav. Ecol. Sociobiol.* 28: 85-90.

Moreby, S.J. (1997) The effects of herbicide use within cereal headlands on the availability of food for arable birds. *Brighton Crop Protection Conference – Weeds*. BCPC, Brighton. 1197-1202.

Moreby, S.J., Aebischer, N.J., Southway, S.E. & Sotherton, N.W. (1994) A comparison of the flora and arthropod fauna of organically and conventionally grown winter wheat in southern England. *Ann. Appl. Biol.* 125: 13-27.

Moreby, S.J. & Stoate, C. (2000) A quantitative comparison of neck collar and faecal analysis to determine passerine nestling diet. *Bird Study* 45: 109-121.

Moreau, R.E. (1972) *The Palaearctic-African Bird Migration Systems*. Academic Press, London.

Morel, G.J. & Betiem, J. (1992) The use of *Acacia nilotica* riverine forests of Senegal by birds, particularly Palearctic migrants. *Proc. VII Pan-Afr. Ornithol. Congr.* 495-502.

Morris, C. (1993) *Recruiting farmers into conservation: an analysis of farmer participation in agri-environment schemes in lowland England*. Unpublished PhD thesis, Wye College, University of London.

Morris, C. & Potter, C. (1995) Recruiting the new conservationists: farmers' adoption of agri-environmental schemes in the U.K. *Journal of Rural Studies* 11: 51-63.

Morris, D.W. (1991) On the evolutionary stability of dispersal to sink habitats. *American Naturalist* 137: 907-911.

Mortimore, M. (1989) *Adapting to Drought: Famine and Desertification in West Africa*, Cambridge University Press, Cambridge.

Mountford, J.O. & Sheail, J. (1984) Effects of drainage on natural vegetation. In: Jenkins, D. (ed.) *Agriculture and the environment*. ITE, Monks Wood. 98-101.

Nassauer, J.I. & Westmacott, R. (1987) Progressiveness among farmers as a factor in heterogeneity of farmed landscapes. In: Turner, M.G. (ed.) *Landscape Heterogeneity and Disturbance. Ecological Studies* 64. Springer Verlag, New York. 199-210.

National Trust (1995) *Linking People and Places*. The National Trust, London.

Naveh, Z., 1995. Interactions of landscape and cultures. *Landscape and Urban Planning,* 32, 43-54.

Newbold, C. (1989) Semi-natural habitats or habitat re-creation: conflict or partnership? In: Buckley, G.P. (ed.) *Biological Habitat Reconstruction*. Belhaven Press, London.

Newton, I. (1998) *Population Limitation in Birds*. Academic Press, London.

Newton, I. & Perrins, C.M. (1997) Sparrowhawks and songbirds. *Birds* 16: 65-68.

Nisbet, I.C.T. & Medway, L. (1972) Dispersion, population ecology and migration of Eastern Great Reed Warblers *Acrocephalus orientalis* wintering in Malaysia. *Ibis* 114: 451-494.

O'Connor, R.J. (1981) Habitat correlates of bird distribution in British census plots. *Studies in Avian Biology* 6: 533-537.

O'Connor, R.J. (1984) The importance of hedges to songbirds. In: Jenkins, D. (ed.) *Agriculture and the Environment.* ITE Symposium No. 13. Institute of terrestrial Ecology, Cambridge.

O'Connor, R.J. & Shrubb, M. (1986) *Farming and Birds.* Cambridge University Press

Odderskær, P. & Sell, H. (1993) Survival of great tit (Parus major) nestlings in hedgerows exposed to a fungicide and an insecticide: a field experiment. *Agriculture, Ecosystems and Environment* 45: 181-193.

Odderskær, P., Prang, A., Poulsen, J.G., Andersen, P.N. & Elmegaard, N. (1997) Skylark (*Alauda arvensis*) utilisation of micro-habitats in spring barley fields. *Agriculture, Ecosystems & Environment* **62**, 21-29.

O'Donnell, C.F.C. (1996) Predators and the decline of new Zealand forest birds: an introduction to the hole-nesting bird and predator programme. *New Zealand Journal of Zoology* 23: 213-219.

Oreszczyn, S. and Lane, A., 1999. How hedgerows and field margins are perceived by different interest groups. *Aspects of Applied Biology,* 54, 29-36.

Oreszczyn, S. and Lane, A., 2000. The meaning of hedgerows in the English landscape: Different stakeholder perspectives and the implications for future hedge management. *Journal of Environmental Management,* 60, 101-118.

Orions, G.H. & Heerwagen, J.H. (1992) Evolved responses to landscapes. In: Barkow, J.H., Cosmides, L. & Tooby, J. (eds.) *The Adapted Mind: Evolutionary Psychology and the Generation of Culture.* Oxford University Press, Oxford. 555-579.

Pain, D. & Pienkowski, M. (1997) *Farming and Birds in Europe*. Academic Press, London.

Paradis, E., Baillie, S.R., Sutherland, W.J., Dudley, C., Crick, H.Q.P. & Gregory, R.D. (2000) Large-scale variation in the breeding performance of song thrushes *Turdus philomelos* and blackbirds *T. merula* in Britain. *Journal of Applied Ecology* **37**, 73-87.

Parish, T., Lakhani, K.H. & Sparks, T.H. (1994) Modelling the relationship between bird population variables and hedgerow and other field margin attributes. I. Species richness of winter, summer and breeding birds. *Journal of Applied Ecology* 31: 764-775.

Parish, T., Lakhani, K.H. & Sparks, T.H. (1995) Modelling the relationship between bird population variables and hedgerow, and other field margin attributes. II. Abundance of individual species and of groups of similar species. *Journal of Applied Ecology* 32: 362-371.

Payne, R.W., Lane, P.W., Ainsley, A.E., Bicjknell, K.E. Digby, S.A., Harding, S.A., Leech, P.K., Simpson, H.R., Todd, A.D, Verrier, P.J. & White, R.P. (1987) *Genstat 5 Reference Manual*. Clarendon Press, London.

Peach, W.J., Siriwardena, G.M. & Gregory, R. (1999) Long-term changes in over-winter survival rates explain the decline of reed buntings *Emberiza schoeniclus* in Britain. *Journal of Applied Ecology* 36: 798-811.

Peach, W.J., Lovett, L.J., Wotton, S.R. & Jeffs, C. (in press) Countryside Stewardship delivers cirl buntings (*Emberiza cirlus*) in Devon, UK. *Biological Conservation*.

Peal, R.E.F. (1968) The distribution of the Wryneck in the British Isles 1964-1966. *Bird Study* 15: 111-126.

Pearce, F. (1997) Lost forests leave West Africa dry. *New Scientist* 18 January.

Pélissier, P. (1966) *Les Paysans du Sénégal.* Imp. Fabrègue, St-Yrieix.

Perkins, A.J., Whittingham, M.J., Bradbury, R.B., Wilson, J.D., Morris, A.J. & Barnett, P.R. (2000). Habitat characteristics affecting use of lowland agricultural grassland by birds in winter. *Biological Conservation* 95: 279-294.

Perrins, C.M. & Geer, T.A. (1980) The effect of sparrowhawks on tit populations. *Ardea* 68: 133-142.

Persson, B. (1972) DDT content of whitethroats lower after summer stay in Sweden. *Ambio* 1: 34-35.

Piersma, T. (1990) Pre-migratory fattening usually involves more than the deposition of fat alone. *Ringing and Migration* 11: 113-115.

Pilastro, A., Bertorelle, G. & Marin, G. (1995) Winter fattening strategies of two passerine species: environmental and social influences. *Journal of Avian Biology* 26: 25-32.

Potts, G.R. (1986) *The Partridge: Pesticides, Predation and Conservation.* Collins, London.

Potts, G.R. (1991) The environmental and ecological importance of cereal fields. In: Firbank, L.G., Carter, N., Darbyshire, J.F. & Potts, G.R. (eds.) *The Ecology of Temperate Cereal Fields.* Blackwell Scientific Publications, Oxford. 3-21.

Potts. G.R. (1997) Cereal farming, pesticides and grey partridges. In: Pain, D. & Pienkowski, M. (eds.) *Farming and Birds in Europe.*,Academic Press, London. 150-177.

Potts, G.R. (2000) Director General's Report on 1999. *The Game Conservancy Trust Review of 1999.* The Game Conservancy Trust, Fordingbridge.

Potts, G.R. & Aebischer, N.J. (1995) Population dynamics of the grey partridge *Perdix perdix* 1793-1993: monitoring, modelling and management. *Ibis* 137 (suppl.): 29-37.

Poulsen, J.G., Sotherton, N.W. & Aebischer, N.J. (1998) Comparative nesting and feeding ecology of skylarks *Alauda arvensis* on arable farmland in southern England with special reference to set-aside. *Journal of Applied Ecology* 35: 131:147.

Poulton, S,M,C. (1994) Small mammal populations in hedgerows: the relationship with seed and berry production. In: Boatman, N.D. (ed.) *Field Margins: Integrating agriculture and conservation. BCPC Monograph 58.* 133-138. British Crop Protection Council, Farnham.

Pretty, J.N. (1994) Alternative systems of inquiry for a sustainable agriculture. *IDS Bulletin* 25: 37-47.

Pretty, J.N. (2000) An assessment of the external costs of U.K. agriculture. *Agricultural Systems* 65: 113-136.

Pretty, J.N. & Scoones, I. (1989) *Rapid Rural Appraisal for Economics: Exploring Incentives for Tree Management in Sudan.* International Institute for Environment and Development, London.

Prospero, J.M. & Nees, R.T. (1986) Impact of the North African drought and El Nino on mineral dust in the Barbados trade winds. *Nature* 320:735-738, 1986.

Pulliam, R. (1988) Sources, sinks and population regulation. *American Naturalist* 132: 652-661.

Rackham, O. (1986) *The History of the Countryside*. Dent, London.

Rands, M.R.W. (1987) Hedgerow management for the conservation of partridges *Perdix perdix* and *Alectoris rufa*. *Biological Conservation* 40: 127-139.

Rands, M.R.W. (1988) The effect of nest site selection on nest predation in grey partridge *Perdix perdix* and red-legged partridge *Alectoris rufa*. *Ornis Scaninavica* 19: 35-40.

Rausing, S. (1998) Signs of the new nation: gift exchange, consumption and aid on a former collective farm in north-west Estonia. In: Miller, D. (ed.) *Material Cultures: Why some things matter*. UCL Press, London. 189-213.

Redman, M. (1992) *Organic Farming and the Countryside*. British Organic Farmers/Organic Growers Association/Soil Association, Bristol.

Reed, J.D., Rittner, U., Tanner, J. & Wiegand, O. (1992) Nutritive value of leaves and fruits of *Faidherbia albida* and their use for feeding ruminants. In: Vandenbelt, R.J. (ed.) Faidherbia albida *in the West African semi-arid tropics: proceedings of a workshop*, 22-26 April 1991, Niamey, Niger. 43-49.

Reenberg, A. & Paarup-Laurensen, B. (1997) Determinants for land use strategies in a Sahelian agro-ecosystem – anthropological and ecological geographical aspects of natural resource management. *Agricultural Systems* 53: 209-229.

Reij, C., Scoones, I. & Toulmin, C. (1996) *Sustaining the Soil: Indigenous Soil and Water Conservation in Africa*. Earthscan, London.

Rew, L.J., Froud-Williams, R.J. & Boatman, N.D. (1992) Implications of field margin management on the ecology of *Bromus sterilis*. *Aspects of Applied Biology* 29: 257-263.

Robertson, J. & Berg, A. (1992) Status and population changes of farmland birds in southern Sweden. *Ornis Svecica* 2: 119-130.

Robertson, P.A. & Hill, D.A. (1988) *The Pheasant: Ecology, management and conservation*. BSP Professional Books, Oxford.

Robinson, R.A. & Sutherland, W.J. (1999) The winter distribution of seed-eating birds: habitat structure, seed density and seasonal depletion. *Ecography* 22: 447-454.

Rogers, C.M. & Rogers, C.J. (1990) Seasonal variation in daily mass amplitude and minimum body mass: a test of a recent model. *Ornis Scandinavica* 21: 105-114.

Russell, K. & Slater, K. (1985) *The Principles of Dairy Farming*. Farming Press, Ipswich.

Salathé, T. (1991) *Conserving Migratory Birds*. Technical Publication No. 12. International Council for Bird Preservation, Cambridge.

Sall, P.N. (1992) Site effects of *Acacia albida* Del. In: Vandenbelt, R.J. (ed.) Faidherbia albida *in the West African semi-arid tropics: proceedings of a workshop*, 22-26 April 1991, Niamey, Niger. 103-105.

Sall, P.N. (1998) *Etude de l'impact de la regeneration naturelle assiste de* Combretum glutinosum *sur les ecosystemes cultives*. Ministère de l'Environment et de la Protection de la Nature, Sénégal.

Sanderström, K. (1995) *Forests and Water – Friends or Foes? Hydrological implications of deforestation and land degradation in semi-arid Tanzania*. Linköping University, Sweden.

Sanogo, R., Crisafi, G., Germano, M.P., De Pasquale, R. & Bisignano, G. (1998a) Evaluation of Malian traditional medicines: screening for antimicrobial activity. *Phytotherapy Research* 12: S154-156

Sanogo, R., Pasquale, R. & Germano, M.P. (1998b) The antitussive activity of *Guiera senegalensis* J.F. Gmel (Combretaceae). *Phytotherapy Research* 12: 132-134.

Scherr, S.J. & Hazell, P.B.R. (1994) *Sustainable Agricultural Development Strategies in Fragile Lands*. International Food Policy Research Institute, Washington.

Schoonmaker Freudenberger, M. & K. (1993) *Fields, Fallow, and Flexibility: Natural resource management in Ndam Mor Fademba, Senegal.* International Institute for Environment and Development, London.

Schoonmaker Freudenberger, K. (1994) Challenges in the collection and use of information on livelihood strategies and natural resource management. In: Scoones, I. & Thompson, J. (eds.) *Beyond Farmer First: Rural people's knowledge, agricultural research and extension practice*. Intermediate Technology, London. 124-133.

Schifferli, L. (2000) Changes in agriculture and the status of birds breeding in European farmland. In: Aebischer, N.J., Evans, A.D., Grice, P.V. & Vickery, J.A. (eds.) *Ecology and Conservation of Lowland Farmland Birds*. British Ornithologists' Union, Tring. 17-25.

Schroeder, R.A. (1997) "Re-claiming land in The Gambia: gendered property rights and environmental intervention. *Annals of the Association of American Geographers* 87: 487-508.

Schroeder, R. & Watts, M. (1991) Struggling over strategies, fighting over food: adjusting to food commercialization among Mandinka peasants. *Research in Rural Sociology and Development* 5: 45-72.

Schudson, M. (1994) Culture and the integration of national societies. In: Crane, D. (ed.) *The Sociology of Culture*. Blackwell, Oxford. 21-43.

Shepherd, M., Hartley, I.R. & McGregor, P.K. (1997) Natal philopatry and breeding site fidelity of corn buntings *Miliaria calandra* on the Uists. In: Donald, P.F. & Aebischer, N.J. (eds.) *The ecology and conservation of corn buntings* Miliaria calandra. JNCC, Peterborough. 103-114.

Sherry, T.W. & Holmes, R.T. (1992) population fluctuations in a long-distance Neotropical migrant: demographic evidence for the importance of breeding season events in the American Redstart. In: Hagan, J.M. & Johnston, D.W. (eds.) *Ecology and Conservation of Neotropical Migrant Landbirds*. Smithsonian Inst. Press, Washington, D.C.

Short, C., Cox, G., Hallett, J., Watkins, C & Winter, M. (1994) *Implications of Game Management for Woodland Management, Landscape Conservation and Public Recreation*. Centre for Rural Studies, Royal Agricultural College, Cirencester.

Shrubb, M. (1997) Historical trends in british and Irish corn bunting *Miliaria calandra* populations – evidence for the effects of agricultural change. In: Donald, P.F. &

Aebischer, N.J. (eds.) *The ecology and conservation of corn buntings* Miliaria calandra.

Siriwardena, G.M., Baillie, S.R., Buckland, S.T., Fewster, R.M., Marchant, J.H. & Wilson, J.D. (1998) Trends in the abundance of farmland birds: a quantitative comparison of smoothed Common Birds Census indices. *Journal of Applied Ecology* 35: 24-43.

Siriwardena, G.M., Baillie, S.R. & Wilson, J.D. (1999) Temporal variation in the annual survival rates of six granivorous birds with contrasting population trends. *Ibis* 141 (4): 621-636

Siriwardena, G.M., Baillie, S.R., Crick, H.Q.P. & Wilson, J.D. (2000) The importance of variation in the breeding performance of seed-eating birds in determining their popluation trends on farmland. *J. Appl. Ecol.* **37**, 128-148.

Skinner, R.J. & Chambers, B.J. (1996) A survey to assess the extent of soil water erosion in lowland England and Wales. *Soil Use and Management* 12: 214-220.

Smallshire, D. & Cooke, A.I. (1999) Field margins in UK agri-environment schemes. *Aspects of Applied Ecology* 54: 19-28.

Snoo, G.R de, Poll, R.J. van der. (1999) Effect of herbicide drift on adjacent boundary vegetation. *Agriculture, Ecosystems and Environment* 73: 1-6.

Snow, D.W. (1965) The relationship between census results and the breeding population of birds on farmland. *Bird Study* **12**, 287-304.

Sotherton, N.W. (1991) Conservation Headlands: a practical combination of intensive cereal farming and conservation. In: Firbank, L.G., Carter, N., Darbyshire, J.F. &

Potts, G.R. (eds.) *The Ecology of Temperate Cereal Fields*. Blackwell, Oxford. 373-397.

Sotherton, N.W & Page, R. (1998) *A Farmer's Guide of Hedgerow and Field Margin Management*. The Game Conservancy Trust, Fordingbridge. 42pp.

Sparks, T.H. and Robinson, K.A. (1999) Hawthorn berry availability in autumn. *Aspects of Applied Biology* 54: 241-244.

Sperber, D. (1996) *Explaining Culture: a Naturalistic Approach*. Blackwell, Oxford.

Stapledon, R.G. & Davies, W. (1941) *Ley Farming*. Penguin.

Stoate, C. (1995) The impact of Desert Locust *Schistocerca gregaria* swarms on pre-migratory fattening of Whitethroats *Sylvia communis* in the western Sahel. *Ibis* 137: 420-422.

Stoate, C. (1996) The Changing Face of Lowland Farming and Wildlife. Part 2: 1945-1995. *British Wildlife* 7: 162-172.

Stoate, C. (1997) Abundance of Whitethroats *Sylvia communis* and potential invertebrate prey in two Sahelian sylvi-agricultural habitats. *Malimbus* 19:7-11.

Stoate, C. (1998) Abundance of Olivaceous Warblers (*Hippolais pallida*) and potential invertebrate prey in unmanaged *Acacia* woodland. *Bird Study* 45: 251-253.

Stoate, C. (1999) The influence of field boundary structure on breeding territory establishment of Whitethroat *Sylvia communis* and Yellowhammer *Emberiza citrinella*. *Aspects of Applied Biology* **54**, 125-130.

Stoate, C. & Moreby, S.J. (1995) Premigratory diet of trans-Saharan migrant passerines in the western Sahel. *Bird Study* 42: 101-106.

Stoate, C & Szczur, J. (1997) Seasonal changes in habitat use by Yellowhammers *Emberiza citrinella* In: *Brighton Crop Protection Conference – Weeds.* 1167-1162.

Stoate, C., Moreby, S.J. & Szczur, J. (1998) Breeding ecology of farmland yellowhammers *Emberiza citrinella. Bird Study* 45: 109-121.

Stoate, C., Borralho, R.J. & Araújo, M. (2000) Factors affecting corn bunting *Miliaria calandra* abundance in a Portuguese agricultural landscape. *Agriculture, Ecosystems & Environment* 77: 219-226.

Stolt, B-O. (1994) Current changes in abundance, distribution and habitat of the Ortolan Bunting *Emberiza hortulana* in Sweden. In: Steiner, H.M. (ed.), *Ortolan Symposium, Wien.* 41-53.

Sullivan, S., McCann, E., de Young, R. & Erickson, D. (1996) Farmers' attitudes about farming and the environment: a survey of conventional and organic farmers. *Journal of Agricultural and Environmental Ethics* 9: 123-143.

Summers-Smith, J.D. (1989) A history of the status of the Tree Sparrow *Passer montanus* in the British Isles. *Bird Study* 36: 23-31.

Swash, A.R.H., Grice, P.V. & Smallshire, D. (2000) The contribution of the Biodiversity Action Plan and agri-environment schemes to the conservation of farmland birds in England. In: Aebischer, N.J., Evans, A.D., Grice, P.V. & Vickery, J.A. (eds.) *Ecology and Conservation of Lowland Farmland Birds.* BOU, Tring.36-42.

Szép, T. (1995) Relationship between West African rainfall and the survival of central European Sand Martins *Riparia riparia. Ibis* 137: 162-168.

Tapper, S.C. (1979) The effect of fluctuating vole numbers (*Microtus agrestis*) on a poipulation of weasels (*Mustela nivalis*) on farmland. *Journal of Animal Ecology* 48: 603-617.

Tapper, S.C. (1992) *Game Heritage*. The Game Conservancy, Fordingbridge.

Tapper, S.C., Potts, G.R. & Brockless, M.H. (1996) The effect of an experimental reduction in predation pressure on the breeding success and population density of grey partridges (*Perdix perdix*). *Journal of Applied Ecology* **33**, 965-978.

Terborgh, J. (1992) Why American Songbirds are Vanishing. *Scientific American* 56-62.

Thiollay, J.M. (1988) Comparative foraging success of insectivorous birds in tropical and temperate forests: Ecological implications. *Oikos* 53: 17-30.

Thomas, J. (1996) The cultural context of the first use of domesticates in continental Central and Northwest Europe. In: Harris, D.R. (ed.) *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. UCL Press, London. 310-322.

Thomas, M.B., Wratten, S.D. & Sotherton, N.W. (1991) Creation of 'island' habitats in farmland to manipulate populations of beneficial arthropods: predator densities and emigration. *Journal of Applied Ecology* 28: 906-917.

Thomson, D.L., Baillie, S.R. & Peach, W. (1997) The demography and age-specific annual survival of song thrushes during periods of population stability and decline. *Journal of Animal Ecology* 66: 414-424.

Thomson, D.L., Green, R.E., Gregory, R.D. & Baillie, S.R. (1998) The widespread declines of songbirds in rural Britain do not correlate with the spread of their avian predators. *Proc. R. Soc. Lond.* 265: 2057-2062.

Tomlinson, J. (1991) *Cultural Imperialism: a Critical Introduction*. Pinter, London.

Tooby, J. & Cosmides. L. (1992) The psychological foundations of culture. In: Barkow, J.H., Cosmides, L. & Tooby, J. (eds.) *The Adapted Mind: Evolutionary Psychology and the Generation of Culture.* Oxford University Press, Oxford. 19-136.

Trevelyan, G.M. (1944) *English Social History.* Longmans, London.

Tucker, G.M. (1997) Priorities for bird conservation in Europe: the importance of the farmed landscape. In: *Farming and Birds in Europe.* In: Pain, D,J. & Pienkowski, M.W. (eds) Academic Press, London. 79-116.

Tucker, G.M. (1999) Measuring the impacts of agriculture on biodiversity. In: Brouwer, F. & Crabtree, B. (eds.) *Environmental Indicators and Agricultural Policy.* CABI, Wallingford. 89-104.

Tucker, G.M. & Heath, M.F. (1994) *Bird in Europe: Their Conservation Status.* BirdLife International, Cambridge.

Tuomenpuro, J. (1991) Effect of nest site on nest survival in the dunnock. *Ornis. Fennica.* 68: 49-56.

Van Horne, B. (1983) Density as a misleading indicator of habitat quality. *J. Wildl. Manage.* 47: 893-901.

Van der Meulen, H.A.B., de Snoo, G.R. & Wossink, G.A.A. (1996) farmers' perception of unsprayed crop edges in the Netherlands. *Journal of Environmental Management* 47: 241-255.

Van Mansvelt, J.D. (1997) An interdisciplinary approach to integrate a range of agro-landscape values as proposed by representatives of various disciplines. *Agriculture, Ecosystems and Environment* 63: 233-250.

Van Oost, K., Govers, G. & Desmet, P. (2000) Evaluating the effects of changes in landscape structure on soil erosion by water and tillage. *Landscape Ecology* 15: 577-589.

Van Wingerden, W.K.R.E., Musters, J.C.M., Kleukers, R.M.J.C., Bongers, W. & van Biezen, J.B. (1991) The influence of cattle grazing intensity on grasshopper abundance (Orthoptera: Acrididae). *Proc. Exper. & Appl. Entomol.* N.E.V. Amsterdam. 2: 28-34.

Vickery, J., Rowcliffe, M., Cresswell, W., Jones, P. & Holt, S. (1999) Habitat selection by Whitethroats *Sylvia communis* during spring passage in the Sahel zone of northern Nigeria. *Bird Study* 46: 348-355.

Wakeham-Dawson, A. & Smith, K.W. (2000) Birds and lowland grassland management practices in the U.K.: an overview. In: Aebischer, N.J., Evans, A.D., Grice, P.V. & Vickery, J. A. (eds.) *The Ecology and Conservation of Lowland Farmland Birds*. BOU, Tring. 77-88.

Warburton, D. (1997) *Partipatory Action in the Countryside*. Countryside commission, Cheltenham.

Warde, A. (1997) *Consumption, Food and Taste*. Sage, London.

Warkus, E., Beinlich, B. & Plachter, H. (1997) Dispersal of grasshoppers (Orthoptera: Saltatoria) by wandering flocks of sheep on calcareous grassland in southwest Germany. *Verhandiungen der Gesellschaft für Őkologie* 27: 71-78.

Warburton, D. (1997) *Partipatory Action in the Countryside*. Countryside commission, Cheltenham.

Warner, K. (1995) Patterns of tree growing by farmers in eastern Africa. In: Arnold, J.E.M. & Dewees, P.A. (eds.) *Farms, Trees and Farmers: Responses to Agricultural Intensification*. Earthscan, London. 90-137.

Warren, D.M. & Pinkston, J. (1998) Indigenous African resource management of a tropical rainforest ecosystem: a case study of the Yoruba of Ara, Nigeria. In: Berkes, F. & Folke, C. (eds.) *Linking Social and Ecological Systems*. Cambridge University Press, Cambridge. 158-189.

Weisner, J.S. (1980) Work and wellbeing in Savanna environments: physiological considerations. In: Harris, D.R. (ed.) *Human Ecology in Savanna Environments*. Academic Press, London. 421-437.

Westmacott, R. & Worthington, T. (1997) *Agricultural Landscapes: a third look.* Countryside Commission, Walgrave. 125pp.

Wezel, A. & Böcker, R (1999) Mulching with branches of an indigenous shrub (*Guiera senegalensis*) and yield of millet in semi-arid Niger. *Soil and Tillage Research* 50: 341-344.

Wilcove, D.S. (1985) Nest predation in forest tracts and the decline of migratory songbirds. *Ecology* 66 (4):1211-1214.

Williams, G.M. & Bowers, J.K. (1987) Land drainage and birds in England and Wales. *RSPB Conservation Review* 1, 25-30.

Wilson, G. (1996) Farmer environmental attitudes and ESA participation. *Geoforum* 27: 115-131.

Wilson, G. (1997a) Assessing the environmental impact of the Environmentally Sensitive Areas scheme: a case for using farmers' environmental knowledge? *Landscape Research* 22: 303-326.

Wilson, G. (1997b) Factors influencing farmer participation in the Environmentally Sensitive Areas scheme. *Journal of Environmental Management* 50: 67-93.

Wilson, J.D. & Browne, S.J. (1993) *Habitat selection and breeding success of skylarks* Alauda arvensis *on organic and conventional farmland.* British Trust for Ornithology, Thetford.

Wilson, J.D., Morris, A.J., Arroyo, B.E. Clark, S.C. & Bradbury, R.B.(1999) A review of the abundance and diversity of invertebrate and plant foods of granivorous birds in northern Europe in relation to agricultural change. *Agriculture, Ecosystems and Environment* 75: 13-30.

Wilson, J.D., Taylor, R. & Muirhead, L.B. (1996b) Field use by farmland birds in winter: an analysis of field type preferences using resampling methods. *Bird Study* 43: 320-332.

Wilson, J.D. & Griffiths, R. (1997) The relevance of population structure to the conservation of the corn bunting *Miliaria calandra* and other declining species. In: Donald, P.F. & Aebischer, N.J. (eds.) *The ecology and conservation of corn buntings* Miliaria calandra. JNCC, Peterborough. 65-75.

Wilson, J.D., Evans, J., Browne, S.J. & King, J.R. (1997) Territory distribution and breeding success of skylarks *Alauda arvensis* on organic and intensive farmland in southern England. *Journal of Applied Ecology* 34:1462-1478.

Wilson, P.J. (1990) *The Ecology and Conservation of Rare Arable Weed Species and Communities*. Unpublished PhD thesis.

Wilson, P.J. (1994) Managing field margins for the conservation of the arable flora. In: Boatman, N.D. (ed.) *Field Margins: integrating agriculture and conservation*. BCPC Monograph No. 58. 253-258.

Winstanley, D., Spencer, R. & Williamson, K. (1974) Where have all the whitethroats gone? *Bird Study* 21: 1-14.

Woiwood, I.P. & Thomas, J.A. (1993) The ecology of butterflies and moths at the landscape scale. In: Haines-Young, R. & Bunce, R.G.H. (eds.) *Landscape Ecology in Britain*. Working Paper No. 21. Department of Geography, University of Nottingham. 76-92

Wood, R.C. (1995) *The Sociology of the Meal*. Edinburgh University Press, Edinburgh.

Wood, P.J. (1989) Faidherbia albida*: A monograph*. Technical Centre for Agricultural and Rural Cooperation, Wageningen, Netherlands.

Woodford, E.K. (ed.) (1960) *Weed Control Handbook*. Blackwell, London.

Wossink, A.A., de Buck, A.J., van Niejenhuis, J.H. & Haverkamp, H.C.M. (1997) Farmer perceptions of weed control techniques in sugarbeet. *Agricultural Systems* 55: 409-423.

Wratten, S.D. (1988) The role of field boundaries as reservoirs of beneficial insects. In:Park, J.R. (ed.) *Environmental Management in Agriculture: European Perspectives*. Belhaven Press, London. 144-150.

Wright, R.P. (1906) *The Standard Cyclopedia of Modern Agricultural and Rural Economy*. Gresham, London.

Wrightson, J. (1888) *The Principles of Agricultural Practice*. Chapman & Hall, London.

Wynne, B. (1992) Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. *Global Environmental Change*. June 1992.

Yahner, R.H., Morrell, T.E. & Rachael, J.S. (1989) Effects of edge contrast on depredation of artificial avian nests. *Journal of Wildlife Management* 53: 1135-1138.

Young, C., Morris, C. & Andrews, C. (1995) Agriculture and the environment in the U.K.: towards an understanding of the role of 'Farming Culture'. *Greener Environment International* 12: 63-80.

Zoundjihekpon, J. & Dossou-Glehouenou, B. (1999) Cultural and spiritual values of biodiversity in West Africa: the case of Benin and Côte d'Ivoire. In: Posey, D.A. (ed.) *Cultural and Spiritual Values of Biodiversity*. United Nations Environment Programme/ Intermediate Technology Publications, London. 370-371.

Appendix

Species List

English name	Scientific name
Badger	*Meles meles*
Barley	*Hordeum spp.*
Barn owl	*Tyto alba*
Bean	*Phaseolus vulgaris*
Black-bellied sandgrouse	*Pterocles orientalis*
Blackbird	*Turdus merula*
Blackcap	*Sylvia atricapilla*
Blackgrass	*Alopecuris myosuroides*
Blackthorn	*Prunus spinosa*
Blue tit	*Parus minor*
Bramble	*Rubus fruticosa*
Brown rat	*Rattus norvegicus*
Budgeriegar	*Melopsitticus unulatus*
Cabbage	*Brassica oleracea*
Calandra lark	*Melanocorypha calandra*
Carrin crow	*Corvus corone*
Cashew	*Anacardium occidentale*
Chaffinch	*Fringilla coelebs*
Charlock	*Sinapis arvensis*
Chickweed	*Stelleris media*
Chough	*Pyrrhocorax pyrrhocorax*
Cirl bunting	*Emberiza cirlus*
Cleavers	*Galium aparine*

Clover	*Trifolium spp.*
Cocksfoot	*Dactylis glomerata*
Corn bunting	*Miliaria calandara*
Corn buttercup	*Ranucnulus arvensis*
Corn cockle	*Agrostemma githago*
Corn marigold	*Chrysanthemum segetum*
Corncrake	*Crex crex*
Dupont's lark	*Chersophilus duponti*
Elder	*Sambucus nigra*
Eleonora's falcon	*Falco eleonorae*
Fathen	*Chenopodium alba*
Field vole	*Microtus agrestis*
Fieldfare	*Turdus pilaris*
Fox	*Vulpes vulpes*
Golden plover	*Pluvialis apricaria*
Goldfinch	*Carduelis carduelis*
Great bustard	*Otis tarda*
Great reed warbler	*Acrocephalus arundinaceus*
Great tit	*Parus major*
Grey partridge	*Perdix perdix*
Groundnut	*Vigna subterranea*
Harvest mouse	*Micromys minutus*
Hooded warbler	*Wilsonia citrina*
Kale	*Brassica napus*
Knotgrass	*Polygonum aviculare*
Lapwing	*Vanellus vanellus*
Lesser short-toed lark	*Calandrella rufescens*
Lesser spearwort	*Ranunculus flammula*
Lesser whitethroat	*Sylvia curruca*
Linnet	*Carduelis cannabina*

Little bustard	*Tetrax tetrax*
Lucerne	*Medicago sativa*
Magpie	*Pica pica*
Mango	*Mangifera sativa*
Mangold	*Beta vulgaris*
Marsh harrier	*Circus aeruginosus*
Mistle thrush	*Turdus viscivorous*
Night-flowering catchfly	*Silene noctiflora*
Oats	*Avena sativa*
Olive	*Olea europea*
Ortolan bunting	*Emberiza hortulana*
Pea	*Pisium sativum*
Pearl millet	*Pennisetum glaucum*
Pheasant	*Phasianus colchicus*
Pied wagtail	*Motacilla alba*
Pin-tailed sandgrouse	*Pterocles alchata*
Poppies	*Papaver spp.*
Potato	*Solanum tuberosum*
Privet	*Ligustrum vulgare*
Rabbit	*Oryctolagus cuniclus*
Red-backed shrike	*Lanius collurio*
Redpoll	*Carduelis flammea*
Redshank	*Tringa totanus*
Reed bunting	*Emberiza schoeniclus*
Rice	*Oryza spp*
Robin	*Erythacus rubecula*
Roller	*Corocias garrulus*
Ryegrass	*Lolium perene*
Sainfoin	*Onobrychis sativa*
Sand martin	*Riparia riparia*

Sedge warbler	*Acrocephalus schoenobaenus*
Shepherd's needle	*Scandix pecten-veneris*
Short-toed lark	*Calandrella brachydactyla*
Skylark	*Alauda arvensis*
Song thrush	*Turdus philomelos*
Sorghum	*Sorghum bicolor*
Sparrowhawk	*Accipiter nisus*
Sterile brome	*Bromus sterilis*
Stinging nettle	*Urtic dioica*
Stoat	*Mustela erminea*
Stone curlew	*Burhinus oedicnemus*
Swede	*Brassica napus*
Timothy	*Phleum pratense*
Tree sparrow	*Passer montanus*
Turnip	*Brassica rapa*
Turtle dove	*Streptopelia turtur*
Weasel	*Mustela nivalis*
Wheat	*Triticum aestivum*
Whinchat	*Saxicola rubetra*
Whitethroat	*Sylvia communis*
Wild radish	*Raphanus raphanistrum*
Wood mouse	*Apodemus sylvaticus*
Woodlark	*Lullula arborea*
Wren	*Troglodytes troglodytes*
Yellow rattle	*Rhinanthus minor*
Yellowhammer	*Emberiza citrinella*